THE TELEGRAPHIC JOURNAL AND

ELECTRICAL REVIEW.

VOL. XXVII. OCTOBER 17, 1890. No. 673.

CONTENTS:

	PAGE
The Electro-Deposition of Copper	445
The Johnson Storage Battery	446
Electrical Oscillations in Air (*illustrated*)	448
Telephonic Specific Inductive Capacity	452
The Telegraph Department of Queensland	453
The Electrical Resistance of Metals (*illustrated*)	454
The Electric Lighting of Brussels	455
Eickemeyer Winding for Electric Railway Motor Armatures (*illustrated*)	455
The Present Position of Postal Telegraph Clerks	456
The Telpher and Electric Railways of the Edinburgh Exhibition	457
Electric Lighting Regulations	459
Eliminating the Temperature Error in Voltmeters	462
London County Council	462
Notes	463
City Notes, &c.:—Woodhouse and Rawson United	466
The Brazilian Submarine Telegraph Company	467
Traffic Receipts	467
Share List of Electrical Companies	468
The Electro-magnet (*illustrated*) (*continued*)	469
Some General Remarks on Telephone Exchange Construction and Equipment	471
New Patents	473
Abstracts of Published Specifications	474
Identity of Structure between Lightning and the Discharges of Induction Machines	474
A New Safety Lamp for Mines	475
Correspondence:—Electrical Heterodoxy	475
Mutual Telephone Co. and Yorkshire Telephone Co.	475
The National Telephone Co. and Muirhead, Glasgow	475
A Phenomenon, indeed!	476
Candle-Power of Electric Lamps	476

THE ELECTRO-DEPOSITION OF COPPER.

ACCORDING to determinations by Lord Rayleigh and Prof. Roscoe, a current of 1 ampère will in one second throw down from a solution of sulphate of copper ·0050478 grains of the pure metal. To deposit, say, 20 tons in one week of 60 working hours, would require a current of

$$\frac{20 \times 7000 \times 2240}{\cdot0050478 \times 60 \times 60 \times 60} = 287{,}620 \text{ ampères.}$$

Now, according to Sprague, the maximum allowable current for obtaining proper deposition is 18 ampères per square foot of surface of the electrodes; this, with the current above calculated, is equal to

$$\frac{287.620}{18} = 15{,}979 \text{ sq. ft.} = 127 \text{ ft.} \times 127 \text{ ft.}$$

Probably by the use of the burnisher, as in the Elmore process, a more granular form of deposit could be allowed, and a somewhat heavier current be employed per square foot of surface; but, in any case, the latter must be very large indeed. In order that the current named may be possible, the resistance of the circuit under an electromotive force of 1 volt must not exceed—

$$\frac{1}{287{,}620} = \cdot0000034768 \text{ ohm,}$$

and this could not be obtained in a single depositing cell with the plates at a greater distance apart than a few inches only. Placing a number of depositing tanks in series would not make matters any better, for what is gained in one respect is lost in another. It would appear then that to deposit 20 tons per week would involve the use of enormous tanks, worked under conditions which would be practically impossible except at a heavy outlay for plant and tank space.

As regards the cost of deposition, to throw down 1 ton of copper under an electromotive force of 1 volt would require

$$\frac{2240 \times 7000}{\cdot0050478 \times 746 \times 60 \times 60} = 1156{\cdot}7 \text{ H.P. hours,}$$

taking the case of one depositing tank only being used.

Now the average cost in cities of 1 H.P. for one year, taking a working day of ten hours and six working days per week, is known to be about £10, which is equivalent to ·76923d. per hour; to deposit, therefore, 1 ton of copper under a total electromotive force of 1 volt in one depositing tank would cost

$$\frac{1156{\cdot}7 \times \cdot76923}{12 \times 20} = £3{\cdot}7072.$$

If the working electromotive force were less than 1 volt, then the cost would be proportionally less, but this, on the other hand, would involve a great increase in the size of the depositing tanks to enable the required current to pass. Of course the cost per ton would in actual practice be considerably more than the bare theoretical, as calculated above, as wages, factory expenses, depreciation on plant, interest on capital involved, and the many contingencies which will readily occur to everybody, have to be added, and these must be heavy, considering the extremely slow rate at which deposition takes place.

Now to show what occurs in actual working. In a well-known volume on electro-deposition we find the following:—"At the North German Works there are 40 baths arranged in two series of 20; the anode surface in each bath is nearly 325 square feet, giving a total of 13,000 square feet of surface for the whole of the baths. The copper is deposited on the cathodes to the thickness of about $\frac{1}{25}$th inch, and at the rate of about 64 lbs. per hour in all the baths, or 1,760 lbs. per day of 24 hours. The production is 1 lb. of pure copper with a consumption of 0·4 H.P. per hour." It will be seen therefore from this example of operating on a scale of nearly a ton per day that the production necessitates 900 H.P. hours per ton.

At the Elliott Metal Refining Company's Works, near Birmingham, there are employed vats arranged in five series of forty-eight in each. Each vat contains 16 anodes, weighing 26 lbs. each, which are replaced every five weeks, and the operation progresses for 156 con-

secutive hours per week, the yield of copper for the forty-eight baths being approximately 30 lbs. per hour, or about ·65 lbs. per bath per hour.

Taking, then, into consideration the cost of solution, the replacement of anodes, and using a boiler and steam engine as the source of motive power, it is difficult to reconcile the report made by Dr. Hopkinson, who, whatever he may do in theory, will not get his horse-power hour for less than three farthings in practice, with what must be the actual state of affairs, and it is only right and just that the Elmore directors should lay before their shareholders and the public a detailed statement of the actual cost incurred in producing their wares.

It is possible that Mr. Stepney Rawson could help us to this desirable end, or if the authorities which we have mentioned have been erroneously quoted perhaps he will show where the flaw exists, as we hope to return to this subject more fully in another issue.

THE JOHNSON STORAGE BATTERY.

A FORTNIGHT ago we received a letter from Messrs. Ramsden & Co., announcing the shipment from Boston, U.S.A., of a set of secondary batteries, manufactured by the Johnson Electric Supply Company. This letter stated, among other things, that "the battery is entirely novel in its construction, as also the method of combination of the active material and the lead plates, the active element being suspended in a net-work or box of lead—very rigid and firm in construction—while ample allowance is made for the necessary amount of expansion and contraction without the slightest warping or buckling in the plates." Reference was made to various tests undertaken by sundry experts, among which is one experiment "with 30 Johnson cells weighing about 21 lbs. each, running 14 16-candle power lamps from a single charging for 21 hours and 30 minutes, the rate of discharge dropping during this time from between 10 and 11 ampères to about 9¾." The importers of this battery add the following statements:—"We think we have the storage battery of the future, as its capacity, efficiency, and durability, as well as cheapness of construction, are absolutely unprecedented. It is quite indestructible in any legitimate use required of a battery, actual short-circuiting and welding of iron wires upon a single cell having no deleterious effect upon the plates. Ten cells were charged in Boston before shipment, and will be drawn off at the electrical works in Westminster some day next week."

We were naturally anxious to see this remarkable invention, and test the accuracy of the above assertions, so when the invitation to view the cells arrived, we proceeded to the place of exhibition. Mr. Johnson, the inventor, kindly answered numerous questions put by several gentlemen present, showing the method of constructing the plates, and giving the following data upon the cells on exhibition. The set of eleven cells before us had been discharged at the works at Boston, and gave a capacity of 260 ampère hours, working at the rate of 13·5 ampères; the E.M.F. at the commencement was 22 volts, and at the end of the discharge 18·91 volts. The weight of the electrodes in each cell was stated to be 33 lbs.; the total weight of each complete element, however, could not be ascertained. This performance shows no advance whatever upon well-known English types of storage batteries, and the arguments naturally turned upon questions of durability and cost. As to durability, the oldest cells have only been in use for two years, and we were not favoured with a view of samples of that age. As regards cost, we could not see how and why the plates on exhibition should be cheaper than those already in the market.

Mr. Johnson's plates are made of lead and oxides of lead, requiring as much material as any other lead battery. The plates consist of ribbed sheets of lead, perforated in such a manner that a "burr" is left on the inner side of each hole. Two such sheets are placed back to back, and the space between them is packed with a paste of red lead. We have been unable to discover any striking novelty in this construction, and we cannot see why such a lead plate should be "indestructible," no means being taken to prevent the sheet metal becoming oxidised with the rest. Mr. Johnson modestly acknowledged that to bring storage batteries to England was like taking coals to Newcastle, the industry here being more highly developed than in America, and he only yielded to the pressing invitation on the part of his London representatives, who issued the letter above referred to, and who are evidently under the impression that this is "*the* battery of the future." No doubt the "future" will decide whether this is so.

The Vaughan-Sherrin Battery.

WE are pleased to note that M. E. Hospitalier has not left us to do battle alone with Prof. Silvanus Thompson. From the last issue of *L'Electricien* we extract the following, which deals mainly with Dr. Thompson's tests:—"Notwithstanding the confidence we feel in our eminent colleague, it is impossible for us to accept his figures without making one important observation. Dr. Silvanus Thompson estimates at 9d. or 10d. (90 centimes to 1 franc) the price of the Board of Trade unit. But we see, according to the figures published, that there is consumed about 1 kilogramme of zinc, the price of which would not be less than 65 centimes (6½d.). It follows from this that the *special liquid* in which there must be sufficient active matter to dissolve this zinc costs only 35 centimes (3½d.). This seems very improbable, not to say impossible. We always receive with a certain amount of distrust these marvellous batteries that are said to supply electrical energy cheaper than the central distributing stations, and M. Vaughan-Sherrin's special liquid will not make us change our opinion, notwithstanding Prof. Silvanus Thompson's figures, and we are reminded of our great fabulist: 'Ce *liquide spécial* ne nous dit rien qui vaille,' and also of the poet: 'Hélas! que j'en ai vu mourir, de jeunes *piles*.' We hope our readers will pardon the liberty we have taken with the text, in consideration of our willingness to apologise when the miraculous—we beg pardon, the special liquid—becomes known to us."

Telephone Working.

AT a recent paper read before the National Exchange Association, Detroit, America, a rather lengthy description was given by Mr. Carty of the "Bridging Bells" system of working telephone lines. The speaker seemed to be quite unaware that the method described had been for many years in use on the telephone systems worked by the Post Office in this country, and all details in connection with the same carefully worked out. A description of it is given in "The Telephone," by Preece and Maier.

The Electropathic Quack Again.

MR. HARNESS, with his electropathic appliances, is once more to the front. This time it is that staunch conservative evening paper, the *St. James's Gazette*, that he has succeeded in beguiling. We had always imagined that the etiquette of respectable journalism had drawn a broad distinction between the space allotted for subject matter and advertisements, so that the public in reading should not be unwittingly drawn into perusing matter which they believe to be general news but which they find to be "puff," pure and simple. The *St. James's Gazette*, however, appears to have recognised no such difference, but in a recent number has allowed the prominent position which the journal has justly won as a temperate leading evening paper, to be made the means of furthering the ends of Mr. C. B. Harness. Thus, in the No. for October 6th, on the last sheet we find a whole column of matter printed in article type and arranged and headed in article form, solely devoted to the puffing of Mr. Harness's so-called electrical appliances. The editors of daily papers cannot be expected, of course, to be skilled electricians, and mistakes of an exceedingly absurd character with reference to the science are sometimes inevitable, but considering the wide-spread and known existence of quackery, especially of the electrical description, it is hardly too much to expect that reasonable care should be taken to protect the unsuspecting public from confounding advertisement with news items.

Copper.

IN the lectures recently concluded at the Mining Exhibition, some interesting statements were made on the subject of copper. The lecturer on "Mining and Minerals in South Australia," spoke of the first discovery in that country made in 1842, viz., the Kapunda Copper Mine, which produced thousands of tons of ore, at the same time greatly benefitting the colony and bringing it into favourable notice as an important mineral country. Other discoveries quickly followed, and the Burra Burra Mine, which once supported an immense population, marked a new era in the history in copper mining in South Australia. The total amount paid in dividends in this concern was £800,000. After being worked by the original owners for some years, the mine was sold to a new company; but during the past two or three years the mines had not been worked, owing in some degree to the low price of copper, and also to the fact that the deposit then being worked apparently became exhausted. For many years the average yield was from 10,000 to 13,000 tons of ore, averaging 22 to 23 per cent. of copper. Other mines were opened, though the output was less, and many of these were now closed, but it was said that they would be shortly reopened, a fact which the lecturer urged would still further decrease the price of copper. Referring to the great "boom" in copper in 1861, which caused the output to be tremendous, he said that at that period there were working in one mine alone 1,600 men. Copper mining has so far affected the wealth of the country in as much as two mines, opened about 1870, had down to the present time proved of value to the colony to the extent of seven million pounds. The fourth lecture, delivered by Mr. J. C. Gordon Sprigg, dealt with the mining industry in South Africa, in which copper had always played a strong part. Here was situate the Namaqualand copper fields, from which 400,000 tons had been sent to England.

Lamp Candle-powers.

WE publish in our Correspondence Columns a very interesting letter on this subject, to which is attached a valuable table of tests, the like of which, we think, has not hitherto been published. These experiments were carried out by Mr. W. W. Melhuish, the chief-engineer of the station, and we have examined the lamp curves from which the figures have been taken. The superiority of the first-mentioned lamp will not fail to attract attention, but possibly some of the others have been much improved during the two years which has elapsed since the data was obtained.

Cable Laying and Maintenance.

ONE of the clauses in contracts between submarine cable companies and manufacturers constitutes a grievance which, we expect, both parties would gladly see abolished. We refer to the final operation connected with cable submerging, the conditions of which are generally set out as follows:—"The cable shall be maintained and tested for thirty (consecutive) days after the completion of the laying at the sole risk of the contractors." If the cable is likely to go wrong through any inherent defect in its construction, it would show faulty in less time than thirty days. This clause has become customary because nobody has apparently hitherto attempted to show that it is unnecessary; it is a costly business for both manufacturers and owners of cables, and the sooner the maintenance clause is limited to a week, or even less, so much the better for everybody concerned. The public would not only be enabled to send messages at an earlier date, but the cable companies would naturally save vast sums of money which of course the contractors allow for in their estimates, and their shareholders would thus derive extra benefit. Possibly the thirty days' guarantee might have been advantageous in times gone by when cable manufacture and testing were not thoroughly understood, but to-day it is but the perpetuation of an old, and now more or less useless custom, and should, therefore, be either abandoned altogether or so modified as to meet the requirements of modern practice.

Distance of Telephone Working.

IN the article on "Telephonic Specific Inductive Capacity," by Mr. W. W. Jacques, which we publish in our present issue, it is stated that the good speaking limit, or "K R," over a telephone line with a Blake transmitter is 2,000 and with a Hunnings transmitter 4,500. These figures differ materially from those obtained, as the result of numerous experiments, both on aerial lines, underground wires, and artificial cables (combinations of condensers and resistance coils) in this country. The average good speaking limit on overhead copper wires is found to be 10,000, on cables and underground wires 8,000, and on overhead iron wires 5,000, but then a Gower-Bell instrument was used.

ELECTRICAL OSCILLATIONS IN AIR.*

By JOHN TROWBRIDGE and W. C. SABINE.

THE experiments of Hertz on electrical waves have opened a wide field for investigation in electromagnetism. The qualitative results of Henry and of Feddersen have been expressed in a quantitative manner by Sir William Thomson. Hertz, collecting together the results of previous observers, and reasoning upon the factors in the formula of Sir. W. Thomson, which expresses a relation between the capacity of a Leyden jar and the self-induction of the circuit through which this jar is discharged, has detected wave-motion with its nodal points and ventral segments, on a wire over which electrical oscillations take place.

Hertz has also pointed out that the experimental results confirm Maxwell's theory, that light and heat are electromagnetic phenomena, and that all energy comes to us from the sun in electrical pulsations.

There can be no question of the phenomena of so-called resonance discovered by Hertz. Roughly speaking, the results obtained by Hertz resonators satisfy the formula $t = \frac{2\pi}{v}\sqrt{\text{L C}}$ in which t is the period of the electrical oscillations, L is the inductance of the circuit, and C is the capacity of the jar, or that of the terminals between which the electrical discharge takes place.

Prof. J. J. Thomson has based a method of measuring the capacities of dielectrics upon this formula and upon Hertz's work †.

The researches of Feddersen upon electrical oscillations‡ were more quantitative than those of Joseph Henry: and Lorenz §, by his repetition of Feddersen's results, and by his mathematical analysis of them, apparently gave subsequent observers a solid basis for calculation.

The results of Feddersen and of Lorenz were obtained by photography. An image of the electric spark drawn out by means of a revolving mirror was photographed, and the distances between the successive oscillations, shown by dark bands on the photograph, were measured. Lorenz assumed the ratio between the electrostatic units and the electromagnetic units, $v = 300 \times 10^6$ metre, as that of the velocity of light; and by means of the formula $t = \frac{2\pi}{v}\sqrt{\text{L C}}$ obtained a satisfactory agreement between the result of experiment and the theory. He showed, apparently, that a certain lack of agreement between theory and experiment, which Feddersen had noticed, was due to taking the dielectric constant of glass too small.

It will be noticed that the method of Feddersen, by means of which the electrical oscillations are photographed, apparently affords an accurate method of determining v. For the factors L and C occur under the square root, and the percentage errors of determination of L and C, being under the square, are halved. Lorenz did not repeat the entire work of Feddersen, but only obtained a sufficient number of photographs—taken under definite conditions in regard to capacity and inductance of the circuit—in order to measure t, the time of oscillation. The accuracy of the results which can be obtained for v depends upon the limits of accuracy of the measurements of the photographs, and of the determinations of the dielectric capacity for oscillatory charges.

In reasoning upon the mode of electrical oscillations in dielectrics, it occurred to us that the medium of the dielectric must greatly influence the result. At the instant the electrical oscillations occur, the glass of the Leyden jar is subjected to a strain which is more or less periodic. It is not probable that the capacity of a condenser is the same for rapid charges and discharges as for slow ones, and the measurements of capacity by the ordinary slow methods form no criterion of the capacity of glass under electrical influences which last but three millionths of a second. We therefore concluded to employ an air condenser instead of one of glass, in order to detect, if possible, the effect of the medium of the dielectric upon electrical oscillations. In order to obtain sufficient capacity for a suitable spark, we were obliged to use the cylindrical form of condenser. The first condenser we employed was made of sheet zinc and consisted of 19 coaxial cylinders. The inner cylinder had a diameter of 15·1 centim., and the outer one of 60·4; the height of the cylinders was 92 centim.

The capacity was computed from the formula

$$\text{C} = \tfrac{1}{2}\frac{l}{\log\frac{b}{a}};$$

in which l is the height, and b and a are radii.

A correction for the ends was made as follows:—The radius of curvature of the boundary of the cylindrical plates was considered so large in comparison with the distance between them that the boundary was treated approximately as a straight line. We may consider that each zinc cylinder constituted a plate between infinite imaginary planes which were at zero potential, these planes being equipotential surfaces. The zinc cylinder was supposed to have its area extended by a strip of uniform breadth around its boundary, and the surface density was assumed to be the same on the extended plate as on the parts not near the boundary. Following Maxwell (Vol. I. Section 196), we have

$$\frac{\text{B}}{\pi}\log_\epsilon 2\cos\frac{\pi\beta}{\text{B}} \text{ for the correction for length.}$$

$\text{B} = a - b$ = distance between cylinders.
β = thickness of cylinder.
l = height of cylinder.

This air condenser was connected with a circuit of parallel wires, which was carefully strung by means of silk thread through the centre of a large unoccupied room. The length of this circuit was about 50 feet. It returned upon itself to the sparking terminal of the air condenser. The jar was charged by a Holtz machine, which worked fairly well under all conditions of the atmosphere. The revolving mirror was a plane one, 4 × 5 inches, silvered upon the front face. It revolved upon a horizontal axis with an average speed of 3,000 revolutions per minute. The frame which carried the mirror bore also a brass arm provided with a minute brush, which rubbed upon a brass sector let into a large disc of ebonite. When the brush rested upon this brass disc the electrical charge could pass to two terminals of tin, between which the discharge took place. A concave silvered glass mirror, of 313 centim. radius and 16·5 centim. aperture, placed at a distance of 230 centim. from the spark, received the image of the spark and reflected it back to the revolving mirror. From the revolving mirror the image was reflected to a photographic plate, which was at a distance of 259·7 centim. from the rotating mirror.

The adoption of a plane revolving mirror, and a stationary concave mirror of long focus, enabled us to place the photographic plate at a distance from the revolving apparatus, and therefore to employ less speed for the revolving mirror. There was no sensible aberration of the image. Great care was taken to balance the mirror. Its large size and weight made it very important, on account of the danger of the apparatus flying apart, that it should revolve with uniformity. The axis of the mirror was placed horizontally. This precaution proved to be a wise one, for twice during the course of the many runs which were made the mirror flew into pieces; the excursions of the fragments, however, were confined to a vertical plane. This liability to accident is perhaps inherent in a method which employs a large plane mirror. The increased

* From the Proceedings of the American Academy of Arts and Sciences. Advance proof communicated by the authors to the *Phil. Mag.*, October, 1890.

† Proceedings of the Royal Society, June 20th, 1889.

‡ Poggendorff's *Annalen*, vol. ciii., p. 69 (1858); vol. cviii., p. 497 (1859); vol. cxii., p. 452 (1861); vol. cxiii., p. 437 (1861); vol. cxv., p. 336 (1862); vol. cxvi., p. 132 (1862).

§ Wiedemann's *Annalen*, vol. vii., p. 161 (1879).

amount of light which results from the use of a large mirror, however, forms a valuable compensation. The revolving mirror was driven by a gas engine.

In order to determine the speed of the mirror at the instant the spark passed, the following apparatus was devised. The same shaft which carried the revolving mirror also carried a brass cylinder 5 centim. in diameter and 21 centim. long. This cylinder was covered at each trial with paper which was coated with lampblack. A stylus moving along a stationary rod beside the shaft could be made to draw a spiral upon the revolving cylinder. One terminal of a Ruhmkorff coil was connected with the brass cylinder, and the other with the stylus. A second pendulum was made to break the circuit of the primary of the Ruhmkorff coil at intervals of one second, and at the middle point of its swing. When the stylus was drawn along the stationary rod which served to guide it, it was made to release automatically at the beginning of the second another pendulum held up by an electro-magnet. This latter pendulum, at the middle of its swing, discharged the air condenser through the inductance circuit at the instant that the mirror was in a suitable position to reflect the image of the electric spark into the photographic camera. While the stylus was being drawn upon the revolving cylinder, the spark from the Ruhmkorff coil left its trace upon the blackened paper. The record on the chronograph consisted of a strongly marked spiral line of over fifty turns. The two sparks from the Ruhmkorff coil left their trace upon the blackened paper as spires, which therefore measured the number of revolutions of the cylinder between the swings of the pendulum, and thus gave the rate at which the mirror was revolving. The chronograph record enabled us to measure the time to $\frac{1}{5000}$th of a second.

In any operation which requires that an electrical spark should make a record upon a disc or cylinder revolving at great speed, a large Ruhmkorff coil and a strong battery are necessary, especially if the primary circuit of the Ruhmkorff coil is broken by a pendulum. With the ordinary automatic break, such as is commonly employed upon induction coils, the failure of a single break is unimportant. If, however, a single break fails when a pendulum break is employed, the record of the experiment is an imperfect one. An excess of battery power and a large battery are therefore necessary. A metallic breakpiece also was found to be more inconstant for our purposes than a mercury break.

It was found that a certain simplicity of contrivance was necessary in the method of discharging the air condenser through the inductance circuit. No arm connected with the revolving mirror could be trusted to break or make an electrical circuit by throwing in or out any form of switch. The great speed at which it revolved broke all arrangements which were tried. By placing a short stiff brush of minute size upon the end of the flying terminal connected with the revolving mirror, and allowing this brush to rub against a brass plate set in an ebonite circle of 41 centim. in diameter, constancy of action was secured.

In order to obtain the same difference of potential at each run, experiments were first made with various forms of unit jars and pith-ball electrometers. These devices were speedily given up in favour of a simple balance electrometer. One of the pans of a delicate balance was replaced by a metallic disc. A similar disc, which was stationary, was placed immediately below the movable one. By properly weighting the remaining balance pan great delicacy and range of indication were obtained. This apparatus constitutes, in fact, an absolute electrometer. A suitable guard ring can be placed around the movable disc.

When the air condenser had been charged to a definite potential, the movable disc of the electrometer closed an electrical circuit in which was included an electrical bell. The observer stationed at the chronograph, at the instant he heard the bell, drew the carriage connected with the stylus along the guides which kept the stylus on the blackened cylinder.

Calling L the coefficient of self induction, we have

$$\frac{L}{l} = 2 \log \frac{b^2}{a^2} + 1^*$$

in which l is the length of conductors contained between two parallel planes; b the distance apart of the conductors; a the radius of wires.

In our case the effect of the ends was found to be inappreciable. The induction due to the ends can be calculated by the repeated employment of the formulæ for geometric mean distance† for two lines whose directions intersect at right angles.

Lord Rayleigh has given the following formula for inductance under rapid oscillations:—

$$L' = l\left(A + \sqrt{\frac{\mu R}{2\rho l}}\right);$$

in which A is a constant, depending on form of circuit; μ is permeability; R is resistance; $\rho = \frac{2\pi}{t}$, where t is time of oscillation; l is length to and fro of inductance circuit.

The final value of L′ for our case is L′ = 39,697.

The radius of the wire employed was a = ·0501 cm.

The length was measured in three sections:—

No. 1, length	1197·0 cm.,	distance between wires			b_1 = 31·55 cm.
No. 2, „	281·0 „	„	„	„	b_2 = 16·1 cm.
No. 3, „	103·0 „	„	„	„	b_3 = 11·3 cm.

The ohmic resistance of the wires was ·742 × 10^9 for direct current, and 1·54 × 10^9 for alternating currents of period t = ·0000031.

The difficulty in the process of photographing the spark consisted in discharging the air condenser through the induction circuit at the instant the revolving mirror was in a position to reflect the image of the spark to the photographic plate. The terminal connected with the revolving mirror, which allowed the electrical discharge to pass when the mirror was in the desired position, had to be adjusted with extreme care. The speed of the image at the photographic plate was about 1 mile per second.

The photographs were measured by means of a dividing engine. At first an objective of low power was used on the microscope of the dividing engine. It was found, however, that a simple cross hair, unaided by a lens, moving directly against the negative, was better than any eyepiece. Measurements were made of the intervals between the electrical oscillations at both terminals.

In later experiments a smaller air condenser was employed, for reasons which will appear in the conclusions of our paper.

A summary of the details and dimensions employed is given herewith.

Small air condenser (No. 2), cylindrical.
- 19 zinc cylinders.
- Height 30·47 centim.
- Diameter of inner cylinder 7·60 centim.
- Diameter of outer cylinder 25·95 centim.
- Average distance apart ·5 centim.
- Capacity (geometric) 5317·9 absolute units—corrected for the capacity of ends.
- Capacity of wire, 200.

Self-induction in three sections, radius ·0501.
1. Length, 1197.
   Distance apart of parallel wires, 31·55.
2. Length, 281.
   Distance apart, 16·10.
3. Length, 103.
   Distance apart, 11·3

For alternations of slow period.
- Ohmic resistance, ·742.
- Self-induction, 41,090.
- Theoretical time with these values, ·00000310 sec.

For alterations of period, ·00000310 sec.
- Ohmic resistance, 1·54.
- Self-induction, 39,700.
- Theoretical time, ·00000304.

* Maxwell, § 685, vol ii. † Ibid. § 692, vol. ii.

Distance from spark to concave mirror, 230 centim.
Distance from rotating mirror to negative, 259·7 centim.
Sparking distance, ·23 centim.

The following is a sample record (see figs. 5 and 6). Each negative was measured three or more times, and the mean taken. The lengths are given in centimetres. The last line is the time in millionths of a second.

Right Terminal.

·289	·541	·561	·598	·552	·511	·544	·560	
·295	·528	·560	·595	·542	·542	·550	·585	·492
·290	·528	·582	·602	·518	·538	·550	·570	·532
·292	·518	·585	·592	·540				
·291	·529	·572	·597	·540	·528	·549	·572	·512
1·65	3·00	3·24	3·38	3·06	3·00	3·11	3·24	2·90

FIG. 1.

FIG. 2.

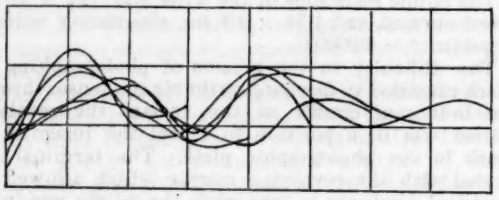


FIG. 3.

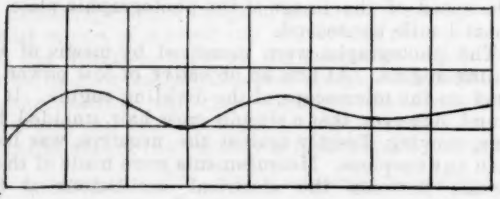
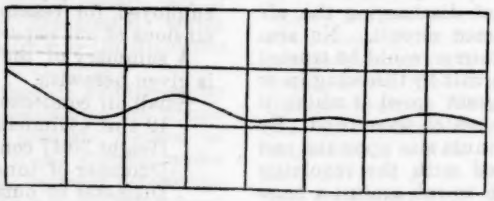


FIG. 4.



Left Terminal.

·461	·611	·582	·522	·508	·551	·554
·464	·609	·567	·543	·500	·585	·556
·462	·607	·574	·532	·502	·570	·542
·462	·609	·574	·532	·503	·569	·551
2·62	3·45	3·25	3·01	2·85	3·22	3·12

Number of revolutions per second, 54·06.
Length of spark, ·23 centim.

The discharge of a glass Leyden jar gave the following values, when reduced to seconds, different lengths of spark being used.

Length of spark.	Terminal.	Time of successive oscillations.					
·4 centim.	Right	1·66	3·22	3·30	3·44		
	Left	3·33	3·37	3·30	3·36		
1·3 „	Right	1·71	3·32	3·45	3·37	3·42	
	Left	3·30	3·43	3·42	3·43	3·42	3·50

Fig. 7 shows that the length of the spark exerts an inappreciable effect.

The following table gives the values in millionths of a second of the successive oscillations on six negatives taken with small air condenser under the conditions given on the preceding page. The first on the right terminal is a half-oscillation. The rest are double oscillations.

Right Terminal.

1·65	3·00	3·24	3·38	3·06	2·91	3·11	3·24	2·90
1·68	3·22	2·99	3·35	3·03	2·97			
1·90	3·11	3·01	3·31	3·00	3·29			
1·95	2·95	3·00	3·08	3·06	3·20	3·03	3·03	3·16
1·62	3·01	3·34	3·04					
1·64	3·18	3·14	3·18	3·03				
1·74	3·08	3·12	3·22	3·04	3·09	3·07	3·13	3·03

FIG. 5.

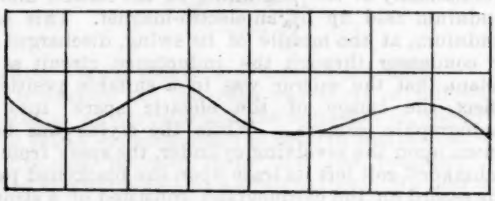


FIG. 6.

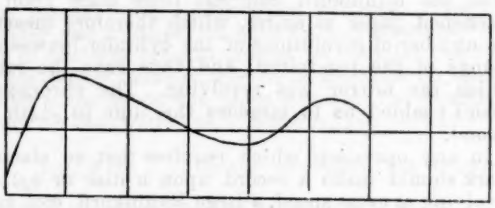
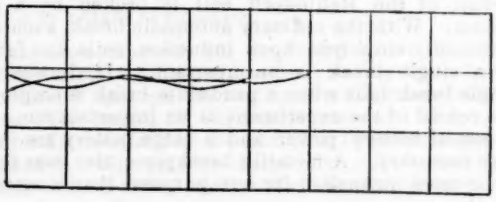


FIG. 7.



Left Terminal.

2·62	3·45	3·25	3·01	2·85	3·22	3·12		
2·89	3·50	3·08	3·21					
3·11	3·12	3·30	2·96	3·35	3·39	3·16	3·06	
2·75	3·63	3·02	2·97	3·48	3·22	3·00	3·18	3·19
2·84	3·19	3·36	2·89	3·41	3·00			
2·88	3·19	3·13	2·90	2·96				
2·85	3·39	3·19	2·99	3·21	3·21	3·09	3·12	3·19

The values for the different negatives are plotted in fig. 1, 2; the mean values, in figs. 3, 4. The time of the first half-oscillation was doubled in plotting. On each ordinate is plotted the time of one oscillation—on the first ordinate the time of the first oscillation, on the second the time of the second. It should be noted that the curved lines are meaningless, except where they cross the vertical ordinates, serving merely to connect the points belonging to one negative.

The difference in the time of oscillations cannot be

explained by the vibration of the discharging arm lengthening and shortening the sparking distance, since this would necessitate a vibration frequency of 100,000 per second, and an amplitude of at least one millimetre; a velocity and momentum impossible for the apparatus either to acquire or endure. This cause also would tend to make the variation range equally above and below the calculated value as the sparking distance increased or diminished.

Another explanation may be sought in the varying ohmic resistance of the path of the spark, although this explanation is inadequate to explain the whole effect. In order to test it, a long (1·3 centim.) and short (·4 centim.) spark were taken from a glass Leyden jar (see fig. 7). Not only could no appreciable difference between the two plates be detected, but there was no variation in the time of successive oscillations.

In regard to the measurement of the negatives on the dividing engine, the following points may be worthy of mention. At the time the measurements were made, it was expected that the sparks from the glass condenser would show the variations, and that the air condenser would give the constant and theoretical period of oscillation. The reverse of this appeared when the results of the measurements were reduced. Moreover, the measurements were made by a run of the dividing engine from one end of the negative to the other; so that if an error was made in the setting of the cross hair on the image of one discharge—for example, making the measurement of that oscillation large—a corresponding amount would be deducted from the measurement of the next oscillation. The result of this would be that if the apparent variations were due to errors in measurement, the periods of discharge would be alternately large and small, or at least as often and as far below the theoretical value as above it. But this is conspicuously not the case.

A consideration of the curves which represent our results shows that with quick oscillations which result from the employment of a small air condenser, the air dielectric did not have time to recover completely, in the time of one oscillation, from the strain to which it was subjected. With the larger air condenser, the oscillations being slower, more time was given for this recovery, and hence the periodicity which we have discovered was not so marked. It seems, therefore, that not only should an electrical resonator be turned for capacity and self-induction, but also for a certain periodicity of strain in the dielectric.

In the case of glass, we should not expect to obtain evidence of this periodical recovery from a quick strain, since it is well known that the recovery from strain is so slow that the discharge from a Leyden jar is incomplete after a discharge lasting a second. The curve we give for glass (fig. 7) shows that this periodical recovery is too slow to manifest itself during the time of quick oscillation.

It is perhaps unnecessary to call attention to the fact that the capacity of a dielectric for rapid discharges is very different from its capacity for slow discharges. In the paper of Lorenz, already cited, the value of the dielectric capacity of glass was determined by slow methods, and used to test an equation in which the capacity of glass appears under very rapid charging and discharging.

Boltzman* and Klemencin† have experimented on the specific inductive capacity of gases and vapours, and it is seen from their results that the agreement between the square root of the capacities of the simple gases and μ, the index of refraction for light of these gases, is quite close, as is demanded by Maxwell's electromagnetic theory of light. A marked difference, however, was found to exist in the case of more complicated molecules—sulphurous acid, or ethyl bromide, for instance. It is probable that the changes of specific capacity of heterogeneous media under rapidly alternating forces constitute an important factor in considering the possible agreement between Maxwell's theory of light and the results of experiment.

In order to see if an intense magnetic field could modify the transmission of electrical waves through a dielectric, the following experiment was tried. A glass Leyden jar, 2·5 centim. in diameter and 28 centim. in height, connected with our inductance circuit, was placed inside a coil consisting of 728 windings of large wire. The outer and inner radii of this coil were 27·7 centim. and 34 centim. Its height was 40·5 centim. The magnetic field in this coil was supplied by a Gramme machine, which gave a current through the coil of approximately 30 ampères. It was expected that a certain amount of the energy spent in producing the electrical waves would be consumed in a reaction on the magnetic field. The total duration of the electrical discharge did not appear to be notably affected by the magnetic field. Certain experiments seemed to show a decrease in the total number of electrical oscillations. A large number of experiments will be necessary to decide upon the effect of a magnetic field upon the passage of electrical waves through a dielectric. The difficulty of obtaining an electrical discharge under the same difference of potential made the experiment an extremely difficult one. The method seems to us to promise a discovery of Maxwell's displacement currents in dielectrics; and we are therefore continuing our researches in this direction with a modified form of apparatus.

Conclusion.

1. The electrical oscillations in the air between the plates of an air condenser show a periodicity extending through the entire range of oscillations. We believe that this periodicity is the analogue of the phenomenon of hysteresis in magnetism. A certain amount of the energy of the electrical discharge is spent in overcoming the dielectric viscosity of the air and in straining the air dielectric. This strain is not immediately released in unison with the electrical surgings.

2. The discussion of our entire results shows unmistakably that electrical oscillations in air are not represented fully by the theoretical equations employed by Hertz. Since the latter writer has taken the term *resonance* from the subject of acoustics, and has given it a new significance in relation to electrical waves, we are tempted to draw also an analogy from the subject of sound. Laplace showed that the discrepancy between the value for the velocity of sound in air calculated from the theoretical equation, and that obtained by experiment, was due to a transformation of energy in heating and cooling the air during the passage of the sound wave. Our experiments on the transmission of electrical waves through the air show also that the values calculated from the theoretical equation do not agree with the experimental values. The discrepancy, we believe, can be explained also by a consideration of the transformation of energy in the dielectric.

3. The periodicity which we have studied is most manifest when the variable capacity of the air condenser bears a suitable relation to the time of the electrical surgings.

4. The electrical waves are apparently unaffected by passing through glass which is placed in an intense magnetic field, the direction of the electrical strain being perpendicular to that of the magnetic strain. The displacement currents of Maxwell in this case do not appear to affect the time of electrical surgings. This conclusion, however, may be modified by experiments which we shall try on a more extended scale.

Telephone License.—We are informed that the Secretary of the Post Office has intimated to Mr. A. Erskine Muirhead, Cart Forge, Glasgow, that he will grant him a license for telephonic communication. This, he claims, will enable him to make a public trial of the French telephones, which was refused him by the National Telephone Company.

* Pogg. *Ann.* cli. p. 403 (1875).

† Abstract of *Journal of the Society of Telegraph Engineers* (1886), p. 108.

TELEPHONIC SPECIFIC INDUCTIVE CAPACITY.*

By WILLIAM W. JACQUES,
Electrician of the American Bell Telephone Company.

IN a paper on "The Construction of Telephone Circuits," read before the American Academy of Arts and Sciences on the 15th of June, 1887, the writer of the present article pointed out "that the readiness with which telephonic conversation may be carried on over any circuit, whether made up of cables or pole lines, or both, depends:—

"1. On the total electrical resistance of the circuit joining together the two stations.

"2. On the total electrostatic capacity of this circuit."

And the general rule was laid down:—"No matter what may be the distance between two points, good business conversation may be carried on between them, provided they be connected by a pole line or cable, or both, the product of whose total resistance by its total capacity is less than 2,000, if transmitters of the Blake type be used, and less than 4,500 if transmitters of the Hunnings type be used."

This rule was enunciated as the result of an extended series of experiments carried out in England, France, Germany, and the United States on pole lines, cables, and mixed pole and cable lines, varying widely in mechanical and electrical dimensions.

The same law, only applied to the transmission of signals through submarine cables, had been previously worked out mathematically by Sir William Thomson, and amply confirmed by experience, so that to-day there can be no doubt of its truthfulness. It is evident, therefore, that in the construction of a telephone line, it is desirable to reduce both the *resistance* and the *capacity* to a minimum.

In a pole line, since the wire is suspended high above the earth, the capacity is always small, and the resistance is the factor that we must try to keep down. In cable lines, however, where the conductor is necessarily brought near to other conductors, or a metal shield, or the earth, the capacity becomes quite an important factor to be respected. In lines made up, as is most generally the case, of a comparatively short section of cable and a larger section of iron pole wire, the capacity of the cable becomes pre-eminently the factor to be respected; for, since the limit of conversation is here determined by the product of the capacity of the cable and the resistance of the whole line, a small percentage of saving in the capacity of the cable gives an enormous gain in the readiness with which conversation may be carried on over the line.

It becomes of vital importance, therefore, to choose an insulating material for telephone cables of low specific inductive capacity. Further than this, since it is well known (Gordon's "Electricity and Magnetism," Chap. XI.) that the specific inductive capacity of any insulating material, and consequently the capacity of any cable insulated with it, is very different for telephone currents from what it is for telegraph currents, because the charge and discharge take place so much more frequently, we may say that it is of vital importance to choose an insulating material of low "telephonic specific inductive capacity," using this expression in contradistinction to "telegraphic specific inductive capacity," by which we mean the values measured in the old-fashioned way.

In the *Proceedings* of the American Academy for December 11th, 1889, Messrs. Safford and Holman, two graduates of the Massachusetts Institute of Technology, in the Department of Electrical Engineering, have published the following table of telephonic specific inductive capacity of various insulators used in cable construction. This table is a result of an elaborate and careful research undertaken by them.

TABLE OF SPECIFIC INDUCTIVE CAPACITIES, MEASURED BY TELEPHONE CURRENTS.

1. Petroleum	1·6
2. Solid paraffin	2·0
3. Cotton saturated with paraffin in vacuum	2·0
4. Cotton boiled in paraffin	2·6
5. India-rubber	3·7
6. Artificial gutta-percha	3·9
7. Gutta-percha	4·2
8. Glass	4·6
9. Water	6·3

Realising that these results were of great practical importance in the construction of telephone cables, the writer has repeated the experiments of Messrs. Safford and Holman with entirely concordant results.

Let us see some of the conclusions we are obliged to draw from the data thus furnished, and then, in order to confirm these conclusions, we will describe some further experiments in this line.

I. The specific inductive capacity of any insulator used in the construction of telephone cables, and, consequently, the actual electrostatic capacity of any given telephone cable, ought to be measured with charges and discharges of telephonic frequency, and not by the old-fashioned method of measuring capacities by slow charge and discharge. This last is of no value, while the telephonic capacity is of vital importance.

II. The presence of water in an insulating material greatly increases its telephonic specific inductive capacity. An inspection of this table shows that, so far as capacity is concerned, petroleum is the best substance to be used, and doubtless this would be the case were it possible to keep it free from water, but water, we see from the table, has a specific inductive capacity of 6·3, so that its presence in the petroleum raises the capacity from the lowest to the highest in the list.

This observation is borne out by actual experience with cable No. 1 in telephony. When new, and the petroleum dry, it works excellently; but as water finds its way in, the cable rapidly loses its efficiency for telephonic work.

This action of the water is quite different from its action as a *conductor* to produce leakage, for the loss of electricity due to leakage in such a cable that has lost its efficiency from the presence of moisture, is entirely insufficient to account for the deterioration.

So, too, in the cable, No. 4, the presence of moisture exercises a detrimental effect on the power of the cable to transmit telephonic currents, and increases the inductive cross-talk to a degree that cannot be accounted for by the diminished insulation resistance.

It is proposed to show later that the presence of moisture in a lead covered cable, does actually increase very greatly its telephonic capacity, and, consequently, both the retardation and cross-talk.

III. Next to petroleum, solid paraffin is seen to be the best substance to use; but on account of mechanical difficulties it has never been found practicable to coat wires directly with solid paraffin.

If the wires are wound with cotton and then boiled in paraffin, as they are in making cable No. 4, the specific inductive capacity is raised to 2·6, an increase of 30 per cent., which, we have seen, is a very great detriment.

If, however, the wires are wound with cotton, and the air and moisture removed by the aid of heat and a vacuum, and they are then boiled in paraffin, from which the air and moisture have also been removed by heat and vacuum, the specific inductive capacity again falls to 2·0, which is the same as that of solid paraffin. This is the process used in preparing the cable No. 3.

It is probable that the inferiority of cable No. 4, as compared with No. 3, is due largely to the moisture retained in the cotton, which we have seen has a capacity of 6·3.

Leaving the paraffin cables, rubber is the next best, then gutta-percha, and poorest of all is glass; but all of these latter substances have so high a specific inductive capacity as to entirely unfit them for telephonic work.

It now becomes desirable to put this information in

* New York *Electrical Engineer*.

more available form, for the use of those upon whom the selection of the best cables for use in telephone construction devolves.

Accordingly, I have given in the following table, first, the telegraphic capacity; second, the calculated telephonic capacity; and third, the measured telephonic capacity of one mile each of cables Nos. 3, 4, 5 and 7, all constructed on the dimensions of the "conference standard."

The measurements of the cables Nos. 3 and 4 were made on cables actually constructed in accordance with the requirements of the conference standard. Those of the rubber and gutta-percha cables were made on cables of a different specification, but reduced to the conference standard by well known and accurate methods of calculation.

Capacity of One Mile of Conference Standard Cable, in Microfarads.

	Measured telegraphic capacity.	Calculated telephonic capacity.	Measured telephonic capacity.
Cable No. 3	·18	·18	·18
„ „ 4	·19	·24	·26
„ „ 5	·27	·30	·30
„ „ 7	·40	·40	·40

In order to show how great a difference in the practical working of a line this difference in telephonic capacity makes, let us assume a conversation to be carried on between two subscribers, connected by five miles of conference cable, and 40 miles of No. 12 iron pole wire.

Let us first suppose cable No. 3 of the conference specification be used.

Resistance 40 miles No. 12 iron wire = 1,184 ohms.
„ 5 „ cable ... ... = 175 „
Total line resistance ... ... = 1,359 „
Capacity 40 miles No. 12 iron wire (30-foot poles), = ·48 microfarad.
Capacity 5 miles Nos. 3 cable = ·90 „
Total line capacity ... = 1·38 „

Product of total resistance and capacity (1,359 × 1·38) = 1,875, which product, being considerably less than 2,000, shows us that conversation could easily be carried on over such a line with Blake transmitters.

Let us next suppose cable No. 4 of the conference specification to be used.

Resistance 40 miles No. 12 iron wire = 1,184 ohms.
„ 5 „ cable ... ... = 175 „
Total line resistance ... ... = 1,359 „
Capacity 40 miles No. 12 iron wire (30-foot poles), = ·48 microfarad.
Capacity 5 miles cable No. 4 = 1·30 „
Total line capacity ... = 1·78 „

Product of total resistance and total capacity (1,359 × 1·78) = 2,419), which product is considerably above 2,000, and good commercial conversation could not be carried on with Blake transmitters.

THE TELEGRAPH DEPARTMENT OF QUEENSLAND.

THE Report of the Superintendent of Electric Telegraphs, Mr. A. F. Matveieff, concerning the telegraph branch for the year 1889, is briefly as follows:—

Since the last annual report, May 1st, 1889, the total mileage of extensions completed, dismantled lines, &c., deducted, amounts to 473 miles of line, 521 miles of wire. Several hundred miles are in course of construction. There are now 9,662¾ miles of line, and 17,193 miles of wire open for public business.

At the close of 1889 there were 343 stations in daily operation, and 721 officers employed, including those holding appointments in other departments, but exclusive of assistants at country stations (officers' wives), and construction parties. Since April 26th, 1889, 17 new stations have been opened, and one station closed, and 14 official stations added.

The twelve months which ended on March 31st last will long be remembered by the officers of the telegraph branch of the post and telegraph department as a period of unprecedented floods, damage to lines, delays to business, and difficulty and danger in many instances in restoring communication and effecting repairs. The total number of interruptions of all kinds in the southern and western districts was 1,007, caused principally by crosses with telephone wires, faults in railway offices, rotten trees falling and trees blown on lines, crosses caused by high winds, pins broken, insulators and brackets damaged; trees felled on lines by road parties, railway contractors, selectors, and others; damages by lightning (17 only). Also a few by large birds coming in contact with the wires; highly laden teams catching wires; hoop iron, fencing wire, tie wire, and fine wire hanging on main wires, in some instances occasioning serious interruptions before found (many of these, it is even feared, were purposely caused by evil intentioned people); blasting operations, land slips, &c., &c. An interruption was also caused by a large snake twisted in the wires, and another by flying foxes.

The expenditure on maintenance and repairs for 1889 was as follows:—Southern and Western districts, £5,473 7s.; Northern district, £3,769 13s. 11d.; total, £9,243 0s. 11d.

So far as interruptions to the cables are concerned, this has been the most unfortunate year experienced. On the 3rd of May, 1889, the cable at Flat-top Island was broken by a steamer's anchor, and hardly had the officer sent to repair it returned to Brisbane, when another misfortune of the kind occurred. Its position was then altered, and about a knot of new cable inserted. It worked well till January of this year, when it was again damaged by the heavy gale blowing at Mackay in that month; this necessitated another repairing job and the expenditure of 450 fathoms of new material. In May, last year, a bad interruption to the Thursday Island cable was caused by the A.U.S.N. Company's steamer *Victoria* drifting down, fouling, and tearing it from its moorings on the Thursday Island beach. The harbour authorities at once took steps to, if possible, recover the end, but were unsuccessful, this cable being of a very heavy type, and beyond the power of any appliances that might have been on the island to recover and re-lay. Very fortunately, the Eastern Extension Cable Company's steamer *Sherard Osborne* was on her way through Torres Straits to New Zealand at the time, and the General Inspector N.D. (Mr. Bourne), who had been sent from Bowen at the first intimation of the disaster, succeeded in making arrangements for the vessel named to pick up, repair, and re-lay the cable. A new piece of 350 fathoms had to be inserted, so much damage had been done.

Recently the cable between Woody and Fraser's Islands showed symptoms of leakage, which quickly increased. The electrician (Mr. Starke) went up as soon as possible, and, discovering the fault, found it advisable to insert about 55 fathoms of new. This, with the interruption of two small cables near Brisbane completes the list.

At the present moment all the submarine wires are working perfectly.

Since last report the new Telephone Central Exchange has been completed, the multiplex board fitted, and the wires removed from the old exchange. More of the Felton-Guilleaume cable has been brought into circuit, and is most satisfactory in its working. The various country exchanges are working well, and although in some places the number of subscribers has decreased there is every reason to expect, with a revival of business, an increased number of applications for connection with the exchanges.

THE ELECTRICAL RESISTANCE OF METALS.

By M. H. LE CHATELIER.

I HAVE shown, in a previous communication (*Comptes Rendus*), how the determination of electrical resistances can be turned to account for the study, at high temperatures, of the molecular transformations of metals. I propose to-day to extend the applications of this method to a new series of metals and alloys.

The metals that show no molecular transformation before fusion, possess electrical resistances, the variation of which is a linear function of the temperature. Here are some examples :

Resistance in ohms of wires 1 millimetre in diameter.

Pt	0·140	+	0·000325 t
Pt + 10 per cent. Rh.	0·335	+	0·000350 t
Cu	0·032	+	0·000101 t
Cu + 10 per cent. Sn.	0·150	+	0·000109 t
Cu + 20 per cent. Ni.	0·420	+	0·000110 t
Ag	0·023	+	0·000105 t

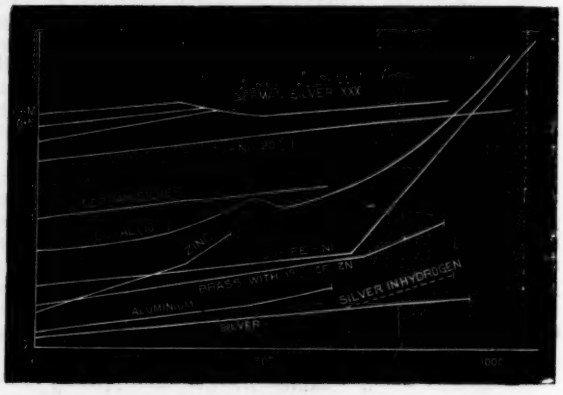
It will be observed that copper, silver and their alloys have an incremental coefficient that is to all intents identical, amounting to about 0·000105 ; that of platinum and its alloys is three times as great. Generally speaking, the introduction of small quantities of foreign substances into a metal raises its resistance curve, causing it to take a direction parallel to its original position. Silver showed an interesting peculiarity. On being heated in oxygen, its resistance curve remained perfectly rectilinear, its mechanical properties were not modified, and its melting point was found to be 945°, given by M. Violle. When, on the other hand, it was heated in hydrogen, all its properties were modified after 650° ; the electrical resistance increased more rapidly than in oxygen ; the metal, after cooling, was extremely fragile ; wires ·25 of a millimetre in diameter could be bent without being broken. And, lastly, the melting point fell to 915°. The metal assumes a dull appearance similar to that occasioned in palladium by the decomposition of its hydruret (hydrure). These facts show that silver absorbs hydrogen at red heat. I found that the quantity of hydrogen absorbed is insufficient to form a definite combination and that, after cooling, the metal does not retain it in any appreciable quantity.

Many metals show, like iron, sudden molecular changes, produced at certain fixed temperatures. At these temperatures the electrical resistances undergo no change on passing one of these points of transformation as it does at the melting points. The accompanying curves give different examples of these phenomena. They were most clearly shown with an alloy consisting of Cu = 70, Ni = 18, Fe = 11. The temperatures at which molecular transformations occurred were found to be for the three following metals :

Zn.	Brass containing 38 per cent of Zn.	Alloy—Cu—Fe—Ni
360°	720°	690°

I ascertained directly in the case of brass that the transformation is accompanied by a considerable absorption of latent heat.

Some alloys show progressive molecular transformations, reminding one of those observed in the chemical equilibrium of saline solutions, in solutions of salts of chromium, of chloride of copper, &c. The transformation is not sudden, but is more often effected within certain limits of temperature. This is the case with slightly silicious aluminium bronze, the transformation of which takes place between 550° and 650°. It is above this last temperature that the tempering of the metal is effected. But this peculiarity is shown in a marked degree in German silver and in alloys of copper and nickel. When these alloys are heated, their resistance decreases rapidly between 300° and 500°. In order to observe this phenomenon, it is indispensable that we should obtain metal that has been annealed (recuit) and cooled very slowly. In the case of German silver, we can only avoid its being almost completely tempered, by making the fall of temperature from 500° to 300° occupy several hours. The transformation seems also to be impeded by the presence of small quantities of foreign matter ; in any case the extent of the transformation varies considerably in different samples of metal, and may even be altogether absent, as in the case of the sample of copper alloyed with 20 per cent. of nickel (Cu-Ni 20 to 100). the resistance of which was given at the beginning of this note.



The following figures relate to three samples chosen from among a dozen that were tested :—

	0.	200.	300.	400.	600.	760.	900.
Cu 50	0·465	0 480	0·505	0 520	0 518	0·530	0 552
Ni 24	0·495	0 513	0·527	0·525	0·518	0·530	0·552
Zn 25	0·514	0·527	0·537	0·525	0·518	0·530	0·552
Cu 66							
Ni 11	0 285	0·308	0·320	0·330	0·338	0·352	0·360
Zn 22							
Cu 81	0·485	0·497	0·500	0·492	0·475	0·473	0 492
Ni 18							

The first of these alloys showed the most marked transformation. The three series of measurements were taken from the heating of specimens cooled at different degrees of rapidity, and consequently unequally tempered.

These experiments give the reason of the fact, already observed, that standard resistances of German silver change in course of time ; the magnitude of their resistance increases. This is because the wires employed are always partially tempered, and become annealed spontaneously under the influence of slight variations of temperature, of mechanical action, or even of the weather merely. We observe with wires of tempered steel a similar spontaneous annealing action, which is shown by a variation of resistance of a contrary sign.

In conclusion, I will give a table of the results obtained with alloys of iron and nickel. Certain of these alloys show, on being heated and cooled, different

Percentage of nickel.	Temperature.	0	200	460	600	800	1000	Points of transformation.
5	Rising	0·36	0·45	0·59	0·90	1 38	1·50	680° and 830°
	Falling	0·36	0·54	0·77	1·35	1·45	1·50	600°
25	Rising	0·98	1·15	1·30	1·42	1·51	1·55	none
	Falling	0·98	0·81	1·10	1·42	1·51	1·55	550°
35	Rising and falling	0·59	0·84	1·04	1·10	1·13	1·18	400°
50	Rising and falling	0·46	0·80	1·14	1·28	1·32	1·36	460°

resistances, *i.e.*, the transformations produced by the elvation of temperature are not immediately reversible ; they do not take place when the temperature falls again until it is nearly same as the surrounding atmosphere.

It will be observed that iron, nickel and their alloys show at temperatures above the transformation point, a law of variation of electrical resistance which is analogous to that of platinum and its alloys. At lower temperatures, on the contrary, the rate of variation is infinitely more rapid.

THE ELECTRIC LIGHTING, &c., OF BRUSSELS.

THE following report on electricity has just been issued by the authorities of Brussels :—The question of the electric lighting of the city has not yet received a solution. The offers made after the publication of the particulars last year by the council, gave rise to a serious discussion of the subject by the electricity committee. It was recognised that it was not advantageous to give attention to one or other of these offers any more than to those which had been made previously. It was consequently resolved to again ask for tenders, by indicating, in a detailed specification, the conditions it was thought advisable to impose on the concessionaries. If the offers are not regarded as more favourable than the former, the committee will propose the establishment of the electric light by the administration. The new propositions, which were to be sent in by August 1st last, are now under examination. The small electricity station used for the lighting of the Theatre de la Monnaie, the Hôtel de Ville, and the Grand Place, continued to work with the city's staff.

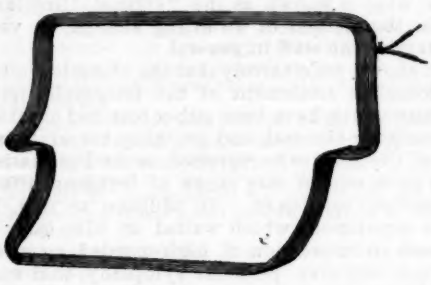


FIG. 1.

The lighting of the theatre had been uninterrupted. Numerous incidents, however, had arisen in the service of charging the accumulators. They had been obliged to raise the conductor cables placed in hooks in the collecting sewers, and fix them on insulators against the vault ; and also, after several repairs of the armatures of the dynamos, the fear of an interruption of the lighting caused the ordering of a new armature. The masonry of the boiler has been replaced and braced. The 20-kilo. accumulators have done good service, and are still in good condition. Inside the theatre alterations have been made to facilitate the playing of an organ, which gave rise to some complaints during the season. The arc lamps, used to project the light on the stage, are now fed by accumulators. For the convenience of the staff, a telephone has been constructed between the theatre and the King's house. The electrical distribution in the Hôtel de Ville has been extended to the sheriff's rooms and to the archives office. An accident which happened recently to one of the provisional masts on the Grand Place, determined the authorities to order the execution of definite supports for the electric lamps which light the place. The communal telegraph service has been improved by the adoption of automatic apparatus in connection with the receivers, and by the establishment of a second apparatus in four divisions of police. In order to improve the service, notably as regards clocks, it was necessary to avoid contact with the telephone wires by placing the wires underground ; but the expense would be too great. As to lightning conductors, which continued to increase, the report gives as a proof of their utility, that during the violent storm of May 18th last, the lightning had struck several points of the outskirts, but nowhere in Brussels itself. The lightning conductors on the telegraph and telephone lines, however, showed numerous traces of the passage of the electric fluid.

EICKEMEYER WINDING FOR ELECTRIC RAILWAY MOTOR ARMATURES.

A NEW departure, says the New York *Electrical Engineer*, has recently been made by the Edison General Electric Company in its electric railway work by the introduction upon its motors of the Eickemeyer method of armature winding, whose use it controls in that class of work. As our readers are aware, the armatures of electric railway motors have generally been wound upon the Siemens system, the main objection to which is that the irregular mass of wire at the end has a tendency to move, abrading the insulation and leading to a short circuit. As the burn out most frequently occurs in the under or inner coils, repairs are unduly expensive.

In the Eickemeyer system of winding, each armature coil, fig. 1, is wound upon a form of peculiar construction, and comes out standard and interchangeable in every respect. In building an armature originally, the laminated iron core is first prepared as in the Siemens armature, and upon this are loosely placed the necessary number of standard coils, which are locked

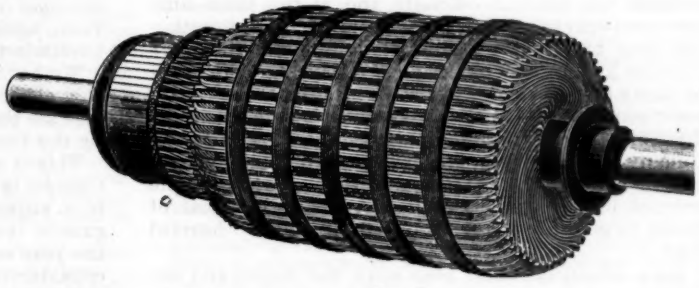


FIG. 2.

in place around the armature by means of the wooden pegs, shown in fig. 2. The result is, a square end both front and rear, instead of the cone-shaped end of the Siemens armature. The coils are held firmly in place, with absolutely no chance for motion, and there is no mechanical pressure from coil to coil which would tend to cause short circuit. The armatures are necessarily of standard diameter and interchangeable, and it is claimed that the Eickemeyer armature will never burn out except from dead over load causing melting of the wire, from accidental mechanical injuries, or from short circuit due to outside causes. If, however, an armature coil should burn out from any of the causes mentioned, it could be replaced without difficulty by any ordinary mechanic and without return to the factory, the whole operation consuming about a day's time and a small amount of material. The local railway company would be provided with a sufficient number of standard coils held in reserve.

Fig. 2 shows the peculiar curvature of the coils at the rear. The same curvature is found at the front end. The whole armature is perfectly ventilated, particularly at the front, where difficulty has frequently occurred. It is the strong belief of the Edison Company that one of the most serious difficulties that has been met with in electric railway work is entirely overcome by this new type of armature they are now manufacturing and using.

THE PRESENT POSITION OF POSTAL TELEGRAPH CLERKS.

DEVOUTLY as the telegraph clerks may desire to put a period to the admittedly necessary remedial campaign which they have carried on for so many years, and satisfactory as the prospect of an equitable settlement of their claims would be to themselves and the public generally, yet it must be evident to all who have followed the subject recently that there is little or no prospect of an immediate closing of the gates of the telegraphic Temple of Janus. The hindrances to this desired end are not difficult to localise, involved as they are in the Postmaster-General's new scheme, and while for a time the rank and file of many of the postal telegraph clerks' battalions may be resting in the enjoyment of such successes as have already been gained, the results of Saturday's conference in Liverpool indicate that victory has not been gained at all points of the field, that it is not general "along the line," and that much has still to be done before the reasonable, and even modest programme, put forward as the sum total of a telegraph clerk's professional claims, receives official recognition.

There may ensue a brief season of comparative rest, when what we will call the "minor tactics" of the forces will probably be reorganised, when those already wearied with the excitement and anxiety of the strife, its many changes and its varied incidents, will recruit their nervous forces and gain rest for the mind.

No one who has not taken part in commercial or social reforms and movements of a similar nature can adequately realise what wear and tear they demand from the mental and vital forces of the human system. In the case of civil servants, an additional strain is enforced on the individual acting, for instance, on an executive committee. He has to display unwearied devotion to his official duty, being careful not to compromise his conduct officially, and at the same time prove not only to his colleagues but also to those in authority over him that his sincerity and his courage are equal to his professional zeal. We have known a rash or hasty step beyond a certain and often an unknown point to result in disaster to the cause, and reduction or dismissal to the individual.

Many of our readers will have read in the wonderful Italian campaigns of Napoleon of the way in which he ordered brigades and battalions, even in the heat of battle, to take what may appositely be called "hurried rests."

How beneficial these rests were the extent and importance of the little Corsican's many victories sufficiently attest. A brief period of tranquility will act, therefore, as a healthy stimulus to further action, and when the telegraph clerks resume their movement they will be more than ever hopeful of gaining those further concessions which they urge will effect a general settlement of their case.

Having referred to the position of the agitation in a military spirit, it does not follow that we are anxious to see further operations carried out in a bellicose fashion; our counsel has ever been in favour of rational and reasonable methods, and few will deny that the telegraph clerks have been uniformly orderly and businesslike.

Upon the whole, the Postmaster-General has approximated his subject fairly well. In clearing off arrears of long standing in such matters as overtime, bank holidays, and an instalment of justice with regard to sick-pay, he well merits the vote of thanks passed most loyally by the Liverpool Conference.

In the matter of increase of salary, he has not been quite so successful. He has stopped short where he was earnestly asked to effect his greatest reform; we refer now to the retention of the old system of classification. Whether this is the outcome of that official advice which he has considered so necessary, and which he has so highly praised, or the indication of doubt and hesitation on his own part is not very certain; on mature consideration we are inclined to think that it is due to the former cause.

The service cries aloud for a progressive system, such as exists in the Savings Bank, the Intelligence Department, the Receiver and Accountant-General's office, and in other departments. The old anomalies will, unless determined agitation be maintained, once more appear; in fact they are still existent.

In judging matters from the classification platform, we ask why such a glaring injustice should be perpetrated as the increasing of the maximum pay of every class in the service *excepting that of the Senior Class of Telegraph Clerks at the Central Telegraph Department*, which has been either studiously and purposely overlooked, or has been treated with entire indifference. As a representative class from which administrative officers are elected, it stands in a worse position now than it did twelve months ago. It must not be forgotten that the grievances complained of are common to all sections of telegraph clerks.

The clerks in this senior class do the duties of superior officials when occasion requires, but no consideration of any kind has been given to them, though they have as good a claim as any other class in the service. The Postmaster-General has admitted in the House of Commons that senior clerks have to perform the duties of assistant superintendents which involves control of staff, arrangement duties, technical and practical knowledge of telegraphy, adjustment of instruments and circuits, &c. Yet the new scheme contains absolutely nothing for them.

Can it be wondered, then, that there is dissatisfaction with classification. Another point, and one almost as glaring, though of a slightly different nature is, that telegraph clerks in receipt of £160 will no longer receive a month's leave annually, though until the introduction of the Postmaster-General's scheme every one in receipt of £150 per annum, or in a class going to that figure, was entitled to a calendar month's leave each year, and this is notified to the Post Office *employés* in what is known as the "Official Circular." Then, again, the method of awarding sick-pay is very unsatisfactory to the staff in general.

We have shown conclusively that the obstacles in the way of a complete settlement of the telegraph clerks case are those which have been either retained or raised by the Postmaster-General, and probably his advisers.

This is all the more to be regretted, as the Postmaster-General is quite within easy range of bringing affairs to a satisfactory conclusion. In addition to this, he gave to the deputations which waited on him early in the year such an impression of high-minded courtesy, consideration, and even personal sympathy, that such flaws and discrepancies in the new scheme, of which the Postmaster-General has publicly claimed a large constructive share, seem altogether at variance with the close and careful attention he devoted to these subjects when originally presented to him.

It would not be right in this case to blame the Treasury officials for any shortcomings in connection with the scheme, for not so very long since, with a dejected air of injured innocence, one of the Treasury officials in the House of Commons avowed meekly that it was not right to blame the Treasury Lords for being parsimonious or inconsiderate; indeed, such was not the case, and especially with regard to the Post Office, they had, indeed, granted every requisition that had been made on them by the Postmaster-General, they having only in view the commercial prosperity of the department and the best interests of the community. This lets a good deal of side light in on the conjuring done in the name of the Treasury, and may confirm the opinion held by well informed people that the Treasury is made the scapegoat of our modern constitutional government.

The speeches delivered at the Liverpool Telegraph Conference were carefully taken down by the "official reporter," who was present under protest, his intrusion being regarded as illegal; the Postmaster-General will therefore, in due course, find out for himself how near he has been to the point at which a general and satisfactory settlement would have been reached, and which many will regret is still left to the future.

THE TELPHER AND ELECTRIC RAILWAYS OF THE EDINBURGH EXHIBITION.*

By E. MANVILLE, M.I.E.E., and J. G. STATTER, A.M.I.C.E.

IT may be said truly of the United Kingdom that its inhabitants are, as a whole, very slow in taking advantage of new applications of the forces of nature; and in no instance, perhaps, is this more so than in the application of electricity to traction. When at last, however, they have taken up a new application, they develop it more thoroughly than other nations.

In a paper on "Electric Traction," read by Mr. Bennett before the East of Scotland Engineering Association last year, he observed that whilst there were but few lines of electric tramway in operation in the United Kingdom, not one of these existed in Scotland. The same condition of affairs pertained at the commencement of this year when, through the enterprise of the council of this exhibition, Scotchmen are enabled to see two examples of the application of electricity to traction at work in their capital.

One of these—the telpherage system—is mainly the invention of the late Prof. Fleeming Jenkin, who developed his ideas in the University of Edinburgh, and therefore this—the first telpher line erected in Scotland—should be especially interesting to you; the other—an electric tramway, worked from overhead conductors—is the first tramway completely worked by this method in the United Kingdom, and this paper is particularly descriptive of these two systems.

TELPHERAGE.

Telpherage is a distinct and special application of electricity to traction particularly suitable for the carriage of goods over rough country where the cost of railways is too great. We do not suppose that it is likely to compete with heavy railways, but it is especially applicable to replace heavy cartage where the cost of transport frequently reaches 1s. per ton mile, which is many times the cost of carrying the same quantity on a telpher line.

Light railways have up to the present time been generally erected to supersede the primitive method of carting when the quantities to be carried reach from 100 to 500 tons per diem. The cost of a light railway where bridges, embankments, and cuttings have to be made is considerable, and far in excess of the cost of a telpher line over the same country. A telpher line spans rivers, crosses roads, bridges, valleys, and generally accommodates itself to the smoothing out of excessive gradients caused by the rough surface of the country, and even when the whole line is erected over a country continually rising from end to end of the line, the telpher locomotive can with facility be made to haul loads up gradients that are quite impracticable on an ordinary railway.

Ingenious devices were invented by the late Prof. F. Jenkin, and brought into practical use, to enable the train to travel automatically without any driver to control it, and a telpher train so equipped goes along the level and ascends gradients and descends gradients at approximately the same speeds, and with a delicacy of regulation that it would be hard to attain in driving a train by by hand.

It is the essential idea of telpherage that, instead of carrying heavy unit loads as in a railway and running but few trains a day to do the work, the unit loads carried should be small and the trains should follow each other frequently. As the trains move across miles of country unattended by a driver, and as the speed of any one train might be greater than that of the one in front, it is necessary to have a system of blocking that shall be absolutely certain, and here electricity lends itself splendidly to the object to be achieved.

With a steam locomotive, the most that can be done to stop it is to shut off the steam from the cylinders, but in an electric locomotive it is possible, so to speak, to remove the fire from the firebox and the steam from the boiler, leaving the locomotive perfectly inert, and in arranging a block system on a telpher line the train in front is arranged to completely cut off the current from the section behind it, so that if the next train should run into this section it immediately loses all power of proceeding until the train in front has moved into a section further on; and thus all possibility of accidents by collision are completely removed.

The telpher line in the grounds of the exhibition measures about 430 yards all round. It is thus necessarily short owing to the space placed at the disposal of the Electrical Engineering Corporation, and does not meet in this short length with all the conditions that exist on lines of greater length and passing over various obstacles, and we therefore propose to describe to you a line recently constructed in Cornwall, which measures nearly three miles all round, and which, passing over country of a difficult nature, involves almost all the conditions that could possibly be met with in telpherage, and the construction of which along its main length is identical with that in the exhibition.

Its use is to convey tin ore from the mine of the Eastpool Tin Company to its stamps. As with the line in the exhibition, it starts with a loop of rigid rail supported in spans of 15 feet, each end of the loop being connected with the up and down flexible lines.

The height of the posts in the mine yard is such that the skeps or buckets which carry the ore only just clear the ground, and are, therefore, in a convenient position for the ore to be shovelled straight into them from the dressing floor. The train, when loaded, proceeds round the loop, passing over buildings in the mine yard and over the boundary walls into the open country, where the line becomes flexible. The posts are here of such a height that the bottoms of the skeps are about 15 feet from the ground, and the whole line ascends a gradient of 1 in 80. Some little distance from the mine yard a curve is reached, and the train leaves the cable to round the curve upon a rigid rail. Shortly afterwards the line crosses a road and then bridges a valley, where the posts rise to a height of nearly 70 feet, maintaining the same gradient and passing directly over the buildings of an ore dressing works and over the end of a row of two-storeyed houses.

After crossing the valley the height of the posts decreases again to about the same height as before, and the second curve is rounded, two more roads being crossed. The line now commences to descend a gradient of 1 in 33 until it reaches a spot rather more than halfway down. Here occurs an abrupt curve, almost a right angle, necessitating the train again leaving the flexible cable and rounding the curve upon a rigid rail. Advantage is taken of this sharp curve to divide the cables and hang requisite ropes upon their ends so as to maintain a constant tension.

Immediately after leaving the compensators the line crosses the high road from London to Penzance, and commences to descend a long gradient of 1 in 26·6. This gradient only ends when the Tolvaddon stamps are reached, where the flexible line terminates, and the train again travels on a rigid rail forming the loop joining the up and down lines at this end. On this loop the train passes the two engine-houses which drives the batteries of stamps, and the skeps are arranged to automatically tip their contents, without stopping, into the receiving hoppers of the stamps.

The engine-houses are fitted with the old type of Cornish engine, in which the beam projects from the engine-house and turns a long crankshaft through a connecting rod about 21 feet in length, and the telpher train passes right over the bob of the engine in the first house at a height of 40 feet from the ground and wends its way beneath the bob of the second engine between the connecting rod and the pump rod. Immediately after the second engine-house the return flexible cable is reached, and the train now travels back empty up the gradient of 1 in 26·6 to the mine yard, where it is reloaded.

The posts supporting the line are constructed in the same manner as those in the exhibition grounds, and consist of two stout baulks of timber, 9 inches by 9 inches, securely bolted and dowelled together and bedded to a considerable depth in the ground, and to these are attached the arms which support the cables. These arms consist of a wrought iron strap with a cast iron strut, one on each side of the post, and where the line is flexible are arranged to swing. This is rendered necessary by the movement in the rope caused by the compensation weights referred to later on; and the saddles to which the cables are directly attached are placed at the extremities of these arms and arranged to rock up and down to enable the train to easily pass over them, and also to swivel in a lateral direction to remain parallel with the rope, notwithstanding the movement caused in the arms by the compensation weights.

As it is necessary not to impede the movement of the ropes produced by the compensation weights when passing round a curve, an arrangement is made for the cables to pass through a junction saddle, so shaped as to allow the train to easily pass from the cable to the rigid rail, the cables then rounding the curve and being kept clear of the rail and other obstructions by the horizontal pulleys shown, passing again away from the rigid rail by means of similar junction saddles. These junction saddles are so designed that the cable is free to move through them, at the same time being firmly supported when the train passes from the cable to the rail.

An arrangement of compensation weights and junction saddles enables the rope to move under the rail, and are much the same as those just referred to. But the cables are ended here and pass over pulleys of larger diameter, and have hung on their ends respectively a weight of about six tons on the side which carries the loaded train, and a weight of about four tons on the side which carries the light train.

The rolling stock for this line consists of three trains, each one carrying five tons of ore. Each consists of 20 skeps, each of a capacity of a quarter of a ton, and two locomotives of about 3 H.P. each. As will be obvious, the rope sags as the train passes in between the posts, and the amount of sag produced by the weight of the train with the compensation weights hung upon the end of the cable is about 4 feet per span on the loaded side, and 5 feet per span on the light side, the spans being about 100 feet. The locomotives are so spaced that one locomotive is always descending a sag whilst the other locomotive is ascending a sag. The same is true of the skeps, so that the train is to all intents and purposes balanced throughout its length, notwithstanding the inclines on the cables over which it passes.

The locomotives are almost exactly similar in construction to those used on the exhibition line. They consist of a framework above the line carrying the driving wheels. From this framework is suspended beneath the line a platform carrying the motor, and the motor is connected through a countershaft by a pitch chain with the driving wheels on the framework above, and the platform containing the motor and gear is so arranged as to swing from the framework above without altering the relative positions of the driving chains and wheels. This is a point of considerable im-

* Paper read at the Edinburgh International Exhibition, before the Royal Scottish Society of Arts.

portance in enabling the locomotives to pass over the sharp incline at the post heads without either of its driving wheels losing grip of the rope.

The countershaft to which the motor is geared carries a special form of centrifugal governor devised by Prof. Fleeming Jenkin, and which automatically cuts off the current from the train when it is proceeding at too great a speed, re-establishing the circuit when the speed has fallen again to the normal.

On the end of the motor spindle is carried a centrifugal brake, which comes into action after the governor has cut off the current and the speed still increases. This is also a design of Prof. Fleeming Jenkin, and we believe we are correct in stating it is the first centrifugal automatic brake ever brought into practical use. It is perfectly reliable, and the loaded trains descend the gradient of 1 in 26·6 by its aid with perfect safety.

The driving wheels of the locomotive are arranged with renewable grooved tyres of a V-shape, which gives an adhesion to the locomotive of about 900 lbs. per ton.

The current is supplied to the line at a difference of potential of about 200 volts. As in the exhibition line, the cables form a return path for the current, a conductor supported on mica insulators carrying the current to the motors, and a small shoe resting on the conductor, and towed along by each locomotive, collects the current.

The duty of the line is about 250 tons per day of 10 to 11 hours working.

The facility with which the curves are rounded will, we believe, commend itself to engineers, and is a distinct advance over a hauling rope aerial railway, at every curve of which a man has to be stationed to push each skep round the rigid rail until it reaches the moving rope again.

This description has purposely been kept as non-technical as possible. That Scotland offers a wide field for the use of telpherage cannot be doubted, and we think we cannot do better than conclude this part of the paper by quoting from Mr. Bennett's paper referred to before, in which he says, "It is only necessary to cast a casual glance at the map of Scotland to perceive that one of its leading characteristics is the absence of railways. Vast tracts of fertile country in Haddington, Berwick, Selkirk, Roxburgh, Peebles, not to mention the more northern counties like Argyle and Inverness, are so many miles from the nearest railway that farmers and other producers are handicapped by the dearth of communication. They cannot compete in the market with rivals more favourably situated on one or other of the existing lines. It would certainly not pay to open up most of these districts, even if a single track and light engine were employed, but they might use telpher lines laid over the public roads, or close beside them."

THE ELECTRIC RAILWAY.

It is not too much to state that the attention of the civilised countries of the world at the present moment is directed to the advance of electric traction as applied to tramways, due to the phenominal development it has achieved in the United States.

But a few years since there were only a few lines of electric tramway in the States, and these altogether experimental lines. At the same period there were over 5,000 miles of horse tramway, and over 100 miles of cable tramway in operation in the United States. To-day there are about 2,000 miles of horse tramway in the States, over 200 miles of cable tramway, and no less than 2,000 odd miles of electric tramway.

In *Duncan's Tramway Manual* for 1890 will be found a statement that the total mileage of the lines opened to traffic in the United Kingdom at the end of 1889 was 940 miles; therefore, the mileage of electrical tramways in the States exceeds the total mileage of all the tramways in the United Kingdom by more than 100 per cent.

To us in this country it is difficult to conceive how three or four companies could have turned out of their factories and set to work such an enormous amount of electrical plant as this represents in so short a time. Evidently, instead of using their time in persuading tramway companies to have their lines worked by electricity, they have devoted all their time to executing orders which must literally have been poured in upon them by the tramway companies.

The large mileage thus being worked in America enables us to form a judgment beyond question as to the cost of operating electrical tramways from fixed conductors, either overhead or underground, and we may take the figure of 3d. per car mile as the total amount for traction; and in the cases of large systems it is certain that this figure would be even less.

Now, the total amount of capital invested in tramways in the United Kingdom is about £14,000,000 sterling, and the average cost of horse traction is certainly above 5d. per car mile. It is, therefore, obvious that an average saving of at least 2d. per car mile would be achieved were the tramway systems in the United Kingdom worked electrically. The total number of car miles run during the year ending June 30th, 1889, in the United Kingdom was 62,000,000, and the saving of 2d. per car mile in the working expenses would represent a sum of over £500,000, which would be a substantial addition to the dividends now paid on the capital invested in tramways.

Surely figures of this kind must appeal to those shareholders who have subscribed this large amount of capital, and who would, immediately their tramways were worked electrically, earn this extra dividend; and if tramway directors are slow of themselves in adopting this successful and economical method of propelling their tramcars, it should be the duty of the shareholders in their own interests to stimulate them to its adoption.

There are, roughly, three methods in which electric tramways may be operated electrically: 1. With conductors supported overhead on poles or wires, as with the line in the exhibition. 2. Conductors laid under the road surface in a conduit. 3. Without conductors at all, the energy being derived from accumulators carried within the car itself.

The first two systems derive their energy at all points of the line from a generating station containing the boilers, engines, and dynamos, or, if there should be water power in the neighbourhood of the tramway, from turbines and dynamos, and these must be kept constantly running as long as the tramcars are in motion. In the third method there is a generating station as before, but the current generated therein, instead of being conveyed direct to the cars by conductors radiating from the station, it is utilised for the charging of batteries of accumulators which are carried by the cars; and the cars, therefore, are not dependent for their motion upon the continuous running of the machinery in the generating station. This, coupled with the fact that the cars can run on any line without alteration to the track—assuming it is strong enough to bear the weight—constitutes the advantage of this system, which, however, cannot at all compare in cost of maintenance with the direct conductor method, and, therefore, will not be dealt with in this paper.

The first method with conductors suspended overhead is the method adopted by an overwhelming large percentage of the electrical tramways in existence. A bare conductor of silicium bronze is suspended overhead, either directly from a bracket attached to a post, if the track runs by the side of the road, or from a cross suspension wire stretched between two posts on either side of the road if the track runs in the centre of the road. This conductor of silicium bronze is insulated from the bracket or from the cross suspension wire, by means of an insulator composed almost entirely of mica, and much stronger and better adapted for the work than an ordinary porcelain insulator.

The size of this bare conductor, or trolley wire, as it is more usually termed, may be any size from No. 6 to No. 2 S.W.G.; and if the length of the tramway and the number of cars running upon it is such that the conductivity of the larger size wire would be too small, another insulated cable is run along the posts supporting the brackets or suspension wires, and tapped at intervals into the bare conductor or trolley wire to reduce its total resistance.

Where turn-outs or crossings occur, points and crossings—of much the same description as those used on the tramway lines underneath—are provided, but, of course, are inverted.

The current is collected from the trolley wire by means of a long, light, and strong swivelling arm mounted on the car roof, at the end of which is either a small wheel or a sliding shoe. The wheel or shoe is kept pressed against the bare conductor overhead by a spring or weight at the other end of the swivelling arm, and this method of maintaining contact with the overhead conductor leaves nothing to be desired in practice. It matters hardly at all how rough the track may be, the collecting shoe remains pressed against the conductor with a pertinacity that is quite phenomenal, and it hardly ever leaves the trolley wire.

The silicium bronze trolley wire being of a very hard nature, and the rubbing surface of the contact shoe or contact wheel being soft, the trolley wire itself hardly wears at all, all the wear being on the sliding shoe or wheel, and these are provided with renewable tyres, which cost but little, and, indeed, the total cost of the wear and tear between an overhead conductor and the sliding shoe or wheel is so little that it is hardly calculable per car mile run.

The City of Boston is supposed to be one of the finest architecturally in the United States, and at the present moment the whole of the tramways of the City of Boston—one of the largest tramway systems in any one town of the world—is being fitted up with overhead conductors. Surely, if there is no objection in a large city like this to the use of overhead conductors under these conditions, in this country there must be numerous opportunities, at least in smaller towns and country lines, for utilising the same simple and efficient method of conducting the current to electric tramcars.

No doubt it requires but the introduction of a few such lines substantially erected to overcome the prejudice of local authorities to the use of overhead conductors.

In the larger towns, however, there is no likelihood of the authorities ever permitting the use of overhead conductors, and then the choice is limited to the use of either the accumulator system or the second method mentioned—viz., conductors laid under the road surface. We do not believe that with the present large depreciation upon accumulator cells this method will find favour with most tramway conductors, and that, therefore, the underground system is destined to be that ultimately used in our larger cities.

Of late there have been advocated several systems in which a closed conduit is used containing a conductor insulated from the earth and brought temporarily into contact with a surface rail divided into sections, as the car passes over these sections. This plan has not, however, been yet brought into operation on any practical scale, and we believe that although such a system might be made to work on a small scale under favourable conditions, it is improbable that with the very unfavourable electrical conditions of an ordinary road, this system could be relied upon for constant satisfactory working.

In the other or open conduit system two methods of constructing the conduit itself, as apart from the electrical fittings it contains, may be used. The first consists of building a conduit

between the two track rails and having upon the surface of the road a slot formed by two rails laid flush with the pavement, and introducing an extra amount of metal in the road, which is more or less objectionable to the local authorities. In March of last year, however, an electrical tramway at Northfleet was opened, in which for the first time the conduit was built underneath one of the running rails, the car wheels on one side travelling on one of the rails forming the slot of the conduit itself. This method of construction meets the objections of the local authorities, as it does not in any way add to the amount of metal placed upon the road surface.

Of open conduit systems with continuous conductors several have been tried without success. The objection to those tried so far, however, has been that the conductor is buried in the conduit, and cannot be got at without ripping open the conduit itself, and, as the size of the conduit must necessarily be small to keep the cost of construction to as low a figure as possible, very imperfect insulators are provided for supporting the conductors within the conduit, and these cannot be got at with facility for cleaning purposes. As a result the insulation is very imperfect and considerable leakage of current usually follows, and any repairs to the conductor necessitates a stoppage of the tramway and a taking up of the road.

To ensure an absolutely reliable open conduit system it is essential (1) that all the electrical fittings should be so designed that they can be placed in position or removed for the purposes of renewal without disturbing the road surface, and they must at all times be easy of access; (2) to ensure good insulation the supports should be as infrequent as possible, and where requisite they should be insulated from the rail by means of efficient insulators; (3) rigid collecting arms should be employed to ensure absolute accuracy of travel, to prevent any risk of contact being broken, and to dispense with points and crossings on the conductor; (4) all the devices used, either electrical or mechanical, must be very simple and cheap.

What is now known as the Waller-Manville system of conduits has been designed with a view to embody all these important considerations. In this system is employed a flexible conductor sufficiently small to admit of its being placed in or withdrawn through the slot. The conductor being flexible, the supports can be at long intervals, such as 30 feet, and can therefore be placed in side openings to the conduit and not in the conduit itself. By this means space is provided for large and efficient insulators. Removable covers are provided to these side openings, or hatchways, giving ready access to the insulators. The insulators are mounted in such a manner that, on removing the cover, they can be at once lifted out.

The collecting arm is so designed that the shank can be withdrawn through the slot, and the collector proper through any hatchway.

Under ordinary conditions the conductor simply rests on supporting arms without being attached thereto. When it is necessary to firmly attach the conductor to its support, as, for instance, on sharp curves, absolute flexibility is still maintained, as the supports are so designed that, whilst rigidly resisting either a longitudinal or lateral strain, the same freedom of upward movement is allowed, as in the case of the conductor itself when unattached.

Simple automatic apparatus is provided at intervals to maintain a constant strain upon the conductor, and to prevent sagging too much between the supports.

The current is collected by means of a U-shaped collector, or shoe, in which the conductor runs, the collector lifting the conductor off the ordinary supports during its travel, and in the case of the supports to which the conductor is attached lifting the support itself.

The conductor rests upon the collecting shoe, which passes clear of the supporting arm of the insulator, allowing the conductor when it has passed to fall back again upon the supporting insulator. This method of collection is similar to that which has been described as having proved extremely efficient with the overhead system.

An automatic tension apparatus is so designed that whilst maintaining a constant tension upon the conductor no extra strain or weight is put upon the collecting arm as it passes beneath the apparatus.

It will be seen, then, that whilst all the conditions which are met with in a tramway are fulfilled, the apparatus employed to fulfil these conditions never interferes with the upward flexible movement of the conductor upon which the perfect contact thus obtained depends; also, that no nuts or bolts, or other means of permanently attaching the insulators and their supports to the conduit, are used. Each insulator with its support is complete in itself, and can be removed from the hatchway instantly for cleaning purposes or renewal. The conductor requires the minimum of work to place it in position, as it is but necessary to drop it through the slot along the road to fasten it to the compensating devices and curve devices, and then the mere action of the collecting shoe passing under the conductor the first time places it in position on the supports along the straight parts of the line.

One of the difficulties hitherto encountered with conduit tramways is that of keeping the conduit itself clear of dirt and road *débris* owing to the obstruction caused by the electrical fittings to the passage of a brush or cleaning device. It will readily be seen that this difficulty does not exist in this system, there being no obstruction to the passage of a brush attached to a car which will sweep the dirt into receptacles provided at the hatch-boxes, from whence it can readily be removed.

Before concluding this paper, we would describe to you the method used on the exhibition tram line for attaching the motors to the tramcars and gearing their armatures up to the car wheels. The same method is used whether the current be supplied from overhead conductors or from underground conductors on a very large percentage of the electrical tram lines now in operation, and experience has proved it to be a very satisfactory method indeed.

The field magnets of the motor are supported in a cradle of gun-metal, which also supports the bearings for the armature and for the countershaft. One end of this cradle terminates in an eye running over a stud supported on a beam carried across the bottom of the car truck, and a flange round the eye rests upon a strong spring; the other end of the cradle terminates in two plummer blocks, which rest directly upon one of the axles of the truck.

The armature is geared to the countershaft by a cast-steel double helical pinion and wheel, and the other end of the countershaft is geared to the car axle by a similar pinion and wheel.

By thus only attaching the motor at one end of the car axle, and allowing it to move to a certain degree radially round the car axle, by supporting at the other end in the way described, great flexibility is obtained, and the effect of the vibrations caused by the wheels travelling over the track and communicated to the motor are thus minimised as far as possible.

Those who are interested in this method of mounting the motor can inspect the arrangement on one of the cars in the grounds, and also any of the other details referred to in this paper.

We have endeavoured to describe to you, in perhaps an imperfect manner, besides the system of telpherage, the methods of working electrical tramways through overhead conductors or underground conductors in an open conduit. The subject is one of pressing interest at the present time, and is worthy of treatment at far greater length than is possible within the limits of this paper; and this must be our excuse for making the descriptions as short as possible, and not entering into many details which in themselves are important.

ELECTRIC LIGHTING REGULATIONS.

MR. COURTNEY BOYLE has forwarded the following copy of regulations issued by the Board of Trade to undertakers under the Electric Lighting Act:—

Regulations and Conditions for securing the safety of the public and for ensuring a proper and sufficient supply of Electrical Energy, made by the Board of Trade under the provisions of the Electric Lighting Acts, 1882 and 1888, and of the Metropolitan Electric Supply Company (West London) Lighting Order, 1889.

Definitions.

In the following regulations—

The expression "the order" means the Metropolitan Electric Supply Company (West London) Lighting Order, 1889.

The expression "the undertakers" means the undertakers for the purpose of the order.

The expression "consumer" means any body or person supplied or entitled to be supplied with energy by the undertakers.

The expression "consumer's terminals" means the ends of the electric lines situate upon any consumer's premises and belonging to him at which the supply of energy is delivered from the service lines.

The expression "consumer's wires" means any electric lines on a consumer's premises which are connected with the service lines of the undertakers at the consumer's terminals.

The expression "aerial conductor" means any conductor which is placed above ground and in the open air.

The expression "pressure" means the difference of electrical potential between any two conductors through which a supply of energy is given, or between any part of either conductor and the earth; pressure on any alternating current system being taken to be the equivalent of pressure on a continuous current system when it produces an equal heating effect if applied to the ends of a thin stretched wire or carbon filament; and—

(*a.*) Where the conditions of the supply are such that the pressure cannot at any time exceed 300 volts, if continuous, or the equivalent of 150 volts, if alternating, the supply shall be deemed a low pressure supply;

(*b.*) Where the conditions of the supply are such that the pressure may exceed the limits of a low pressure supply, but cannot exceed 3,000 volts, or the equivalent of 3,000 volts, whether continuous or alternating, the supply shall be deemed a high pressure supply;

(*c.*) Where the conditions of the supply are such that the pressure may on either system exceed 3,000 volts, or the equivalent of 3,000 volts, the supply shall be deemed an extra high pressure supply.

Mains, service lines, and other conductors and apparatus are referred to as low pressure, high pressure, and extra high pressure mains, &c., according to the conditions of the supply delivered through the same or particular portion thereof.

Provided that in the case of conductors laid under the surface of the ground in conduits, in accordance with these regulations, and being the property or under the sole charge of the undertakers, low pressure conductor shall mean any conductor in which

the pressure between that conductor and the earth cannot at any time if continuous exceed 300 volts, or, if alternating, 150 volts, or between that conductor and any other conductor laid in the same conduit cannot at any time if continuous exceed 500 volts, or, if alternating, 250 volts.

When any casing, support for conductors, conducting wire or other metallic body is required to be efficiently connected to earth, it shall be deemed to be so connected when it is connected to metallic mains for water supply outside of buildings, or, where these are not available, to a mass of metal having a total surface of at least four square feet, buried to a depth of at least three feet in moist earth, by means of a conductor possessing a mechanical strength, and offering a passage to electrical discharges equal to that of a strand of seven No. 16 galvanised iron wires.

The expression "daily penalty" means a penalty for each day on which any offence is continued after conviction thereof.

All other expressions to which meanings are assigned in the order or principal Act have the same respective meanings in these regulations.

I.—Regulations as to Safety.

General.

(1.) Save as hereinafter provided, the supply of energy delivered to the consumer's terminals shall be a low pressure supply.

(2.) A high pressure supply shall not be delivered to any consumer's terminals, except for special purposes, and with the approval of the Board of Trade on the joint application of the consumer and the undertakers, and subject to such further regulations as the Board of Trade may from time to time prescribe. But a high pressure supply may be given to distributing or converting stations or points, or to distributing mains, in accordance with the following regulations.

(3.) An extra high pressure supply shall not be given except to distributing stations or other premises in the sole occupation of the undertakers, and with the written consent of the Board of Trade, and subject to such regulations and conditions as the board may prescribe.

Mains and other Conductors.

(4.) The maximum working current shall not be sufficient to raise the temperature of the conductors or any parts thereof to such an extent as to materially alter the physical condition or specific resistance of the insulating covering, if any, or in any case to raise such temperature to a greater extent than 30° of Fahrenheit's thermometer; and efficient automatic means shall be provided which will render it impossible for this maximum working current by any accident to exceed such limit to the extent of 50 per centum, even for short intervals of time; and special care shall be taken that the cross sectional area and conductivity at joints are sufficient so avoid local heating, and that the joints are protected against corrosion.

(5.) Where any portions of any conductors are exposed in such a position as to be liable to be affected by lightning, they shall be efficiently protected againt accident by appliances of such pattern and construction as may from time to time be approved by the Board of Trade.

(6.) Where any high pressure conductors, other than aerial conductors, are placed above the surface of the ground, they shall be completely enclosed in brickwork, masonry, or cement concrete, or in strong metal casing efficiently connected to earth.

(7.) Where any high pressure conductors are laid in subways, or in the same conduits with any low pressure conductors, they shall be completely enclosed in strong metal casing efficiently connected to earth.

(8.) Where any high pressure conductor is laid within a less distance than 18 inches from any low pressure conductor or from the surface of the ground, or where any low pressure conductor is laid within the above-mentioned distance from any previously laid high pressure conductor, efficient means shall be taken to render it impossible that the low pressure conductor or the surface of the ground shall become electrically charged by any leakage from or defect in the high pressure conductor.

(9.) Every high pressure conductor shall be continuously insulated with a durable and efficient material which shall be protected on the outside against injury or removal by abrasion, and every such conductor shall be tested for insulation after having been laid in position and before any joints for service lines are made. The insulation resistance under these conditions shall not be less in any section of the conductor than at the rate 100,000 ohms per mile for every volt of pressure of the supply under a testing pressure of at least 100 volts, and the undertakers shall duly record the results of the tests of each conductor, or section of a conductor, and at all times permit an electric inspector to examine and take copies of such record.

(10.) The insulation resistance of any complete circuit used for high pressure supply, including all devices for producing, consuming, or measuring energy, connected to such circuit, shall be such that should any part of the circuit be put to earth through a resistance of 2,000 ohms, the leakage current shall not exceed 0·04 ampère in the case of continuous currents, or 0·02 ampère in the case of alternating currents. Every such circuit shall be fitted with an instrument of such pattern and construction as may from time to time be approved by the Board of Trade, which shall immediately indicate any defect which may at any time occur in the insulation resistance of either conductor.

Every such circuit shall be tested for insulation at least once in every week, and the undertakers shall duly record the results of such testings, and at all times permit an electric inspector to examine and take copies of such record.

(11.) In the case of a high pressure supply on any alternating current system, where separately insulated conductors are laid in the same conduit or pass through the same boxes, precautions shall be taken against the discharge of electric sparks between the insulating covering of oppositely charged conductors, by providing a sufficient connection of a conducting nature from one covering to the other throughout.

Conduits.

(12.) All conduits used as receptacles for conductors shall be constructed of durable material, and of ample strength to resist any pressure due to heavy traffic or other forces to which they may be expected to be subjected.

(13.) Where the conductors in any conduit are not continuously insulated, adequate precautions shall be taken to ensure that no accumulation of water shall take place in any part sufficient to raise the level of the water into contact with the conductors.

(14.) All conduits for conductors constructed in streets in which gas mains are also laid, shall be efficiently protected against an accumulation of gas.

(15.) All street boxes shall be efficiently protected against an accumulation of gas or water, and their covers so secured that they cannot be opened except by means of a special appliance.

Converting Stations.

(16.) Converting stations, or points in a system of distribution to which a high pressure supply is given from generating stations, and from which a low pressure supply is given to one or more consumers, and which are not on the consumer's premises, shall be established in suitable places, which are in the sole occupation and charge of the undertakers.

(17.) In every case where the supply is transformed at a converting station as described in the preceding regulation, some means or apparatus approved by the Board of Trade shall be provided which shall render it impossible that the low pressure distributing mains shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high pressure system either within or without the converting station.

Consumer's Premises.

(18.) Where the general supply of energy is a high pressure supply, and transforming apparatus is installed on the consumer's premises, connected to the distributing mains by high pressure service lines, and to the consumer's terminals by low pressure service lines, the whole of the high pressure service lines, conductors, and apparatus, including the transforming apparatus itself, so far as they shall be on the consumer's premises, shall be completely enclosed in solid walls, or in strong metal casing efficiently connected to earth, and securely fastened throughout.

(19.) In every case where any transforming apparatus is installed on the consumer's premises, as described in the preceding regulation, some means or apparatus approved by the Board of Trade shall be provided, which shall render it impossible that the low pressure service lines and consumer's wires shall be at any time charged to a dangerous difference of potential from the earth, owing to any accidental contact with, or leakage from, the high pressure system either within or without the transformer.

(20.) All terminals, low pressure service lines, or other apparatus, between the transforming apparatus or other source of supply and the consumer's terminals, so for as they shall be on the consumer's premises, shall be completely enclosed in insulating cases or coated with insulating material in such a manner that no part of them can be touched by any person without the removal of such case or coating, and, wherever exposed, shall be efficiently protected against injury to the insulation.

(21.) The undertakers shall be responsible for all electric lines, fittings and apparatus belonging to them, or under their control, which may be upon the consumer's premises being maintained in a safe condition and in all respects fit for supplying energy.

(22.) In delivering the energy to the consumer's terminals the undertakers shall exercise all due precautions so as to avoid risk of causing fire on the premises.

(23.) If the undertakers are reasonably satisfied, after making all proper examination by testing or otherwise, that a connection with the earth exists at some part of a circuit of such resistance as to be a source of danger, and that such connection does not exist at any part of the circuit belonging to the undertakers, then and in any such case any officer of the undertakers, and duly authorised by them in writing, may, for the purpose of discovering whether such connection with the earth exists at any part of a circuit within or upon any consumer's premises, at all reasonable times, after giving one hour's notice of his intention to do so, enter any such premises and disconnect the consumer's wires from the service lines, and may require the consumer to permit him to inspect and test the wires and fittings belonging to the consumer and forming part of the circuit.

(24.) If on such testing the officer discovers that a connection exists between the consumer's wires and the earth, and that such connection has an electrical resistance not exceeding 5,000 ohms, or if the consumer does not give all due facilities for such inspection and testing, the undertakers shall forthwith discontinue the supply of energy to the premises in question, giving immediate notice of such discontinuance to the consumer, and shall not recommence such supply until they are reasonably satisfied that such connection with the earth has been removed.

Provided that in cases where the maximum power taken by any consumer exceeds 25,000 watts, the consumer's wires may be divided for the purposes of this testing into separate circuits, the insulation resistance of each of which shall exceed 5,000 ohms.

(25.) If any consumer is dissatisfied with the action of the undertakers either in discontinuing or in not recommencing the supply of energy to his premises, the wires and fittings of such consumer may on his application and payment of the prescribed fee be tested for the existence of connection with the earth by an electric inspector, or if no electric inspector has been appointed, by a person appointed by the Board of Trade.

This regulation shall be indorsed on every notice given under the provisions of the last preceding regulation.

Regulations as to Aerial Conductors where erected with necessary consents.

(26.) An aerial conductor shall not in any part thereof be at a less height from the ground than 20 feet, or where it crosses a street, 35 feet, or within 7 feet of any building or erection other than a support for the conductor, except where brought into a building for the purpose of supply.

(27.) Service lines from aerial conductors shall be led as directly as possible to insulators firmly attached to some portion of the consumer's premises which is not accessible to any person without the use of a ladder or other special appliance, and from this point of attachment to the consumer's terminals they shall be enclosed and protected in accordance with the preceding regulations as to service lines on the consumer's premises.

(28.) Every aerial conductor shall be attached to supports at intervals not exceeding 200 feet where the direction of the conductor is straight, or 150 feet where this direction is curved, or where the conductor makes a horizontal angle at the point of support.

(29.) Every support of aerial conductors shall be of a durable material, and properly stayed against forces due to wind pressure, change of direction of the conductors, or unequal lengths of span, and the conductors and suspending wires (if any) shall be securely attached to insulators fixed to the supports. The factor of safety for the conductors and suspending wires shall be at least six and for all other parts of the structure at least 12, taking the maximum possible wind pressure at 50 pounds per square foot. No addition need be made for a possible accumulation of snow.

(30.) Every support, if of metal, shall be efficiently connected to earth, and if of wood or other non-conducting material, shall be protected by a lightning conductor fastened to its support along its entire length, and projecting above the support to a height of at least six inches, such lightning conductor being efficiently connected to earth.

(31.) Where any aerial conductor crosses a street, the angle between such conductor and the direction of the street at the place of such crossing shall not be less than 60°, and the spans shall be as short as possible.

(32.) Where any aerial conductor belonging to the undertakers is erected so as to cross any other aerial conductor or any suspended wire used for purposes other than the supply of energy, precautions shall be taken by the undertakers against the possibility of their conductor coming into contact with such other conductor or wire, or of such other conductor or wire coming into contact with their conductor by breakage or otherwise.

(33.) Every high pressure aerial conductor shall be continually insulated with a durable and efficient material to be approved by the Board of Trade to a thickness of not less than one-tenth part of an inch, and in cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation shall not be less in inches or parts of an inch than the number obtained by dividing the number expressing the volts by 20,000. This insulation shall be further efficiently protected on the outside against injury or removal by abrasion. If this protection be wholly or partly metallic it shall be efficiently connected to earth.

(34.) The material used for insulating any high pressure aerial conductor shall be such as will not be liable to injurious change of physical structure or condition when exposed to any temperature between the limits of 0° and 150° Fahr., or to contact with the ordinary atmosphere of towns or manufacturing districts.

(35.) Every aerial high pressure conductor shall be efficiently suspended by means of non-metallic ligaments to suspending wires, so that the weight of the conductor does not produce in it any sensible stress in the direction of its length, and the insulated conductors and suspending wires, where attached to supports, shall be in contact only with material of highly insulating quality, and shall be so attached and guarded, that in case they break away it shall not be possible for them to fall away clear of the support.

(36.) The undertakers shall be responsible for the efficiency of every support to which their aerial conductors are attached, and every such support shall be marked to indicate the ownership of the conductor.

(37.) Every aerial conductor belonging to the undertakers, including its supports and all the structural parts and electrical appliances and devices belonging to or connected with it, shall be duly and efficiently supervised and maintained as regards both electrical and mechanical conditions.

(38.) The undertakers shall not permit any aerial conductor to remain erected after it has ceased to be used for the supply of energy, unless they intend within a reasonable time again to take it into use.

Penalties.

(39.) If the undertakers make default in complying with any of the preceding regulations they shall be liable to a penalty not exceeding £10 for every such default, and to a daily penalty not exceeding £10.

The imposition of any penalty under this regulation shall not affect the liability of the undertakers to make compensation in respect of any damage or injury which may be caused by reason of such default.

II.—REGULATIONS AS TO SUPPLY.

(1.) One week at least before the undertakers are ready to commence to supply energy through any feeding, charging, or distributing mains, they shall serve a notice upon the County Council and the local authority of their intention to commence such supply.

(2.) From and after the time when the undertakers commence to supply energy through any distributing mains, they shall maintain a supply of sufficient power for the use of all the consumers for the time being entitled to be supplied for such main; and such supply shall, except so far as may be otherwise agreed upon from time to time between the County Council and the undertakers, be constantly maintained at such pressure as may be fixed under the provisions of these regulations. Provided that, for the purposes of testing, the authority by whom the electric inspector is appointed may give permission to the undertakers to discontinue the supply at such intervals of time and for such periods as it may think expedient, and that for any other purposes connected with the efficient working of the undertaking, the undertakers may, with the permission of the Board of Trade discontinue the supply at such intervals of time and for such periods as the Board of Trade may think expedient. Where the supply is so discontinued, notice of such discontinuance, and of the probable duration thereof, shall be forthwith served upon the County Council and the local authority.

(3.) The system of distributing mains shall be so arranged in sections, that in case it becomes necessary to stop the supply through any portion of a main for more than one hour, for the purposes of repairs, or for any other reason, the stoppage of supply will in no case exceed in amount a maximum power of 200,000 watts, or extend to the premises of more than 80 consumers, and in the case of every stoppage for more than one hour, reasonable notice shall be previously given by the undertakers to every consumer affected thereby except in cases of emergency.

(4.) During the whole of the period when a supply of energy is required to be maintained by the undertakers in the distributing mains under the order and these regulations, it shall be maintained at a constant pressure (in these regulations termed "the standard pressure") to be fixed as hereinafter specified; but such standard pressure may be different for different portions of the distributing mains. Provided that the undertakers shall be deemed to have complied with the requirements of this regulation so long as the pressure does not at any point vary more than three per cent. from the corresponding standard pressure in the case of a general supply at low pressure, or two per cent. in the case of a general supply at high pressure, unless changes in pressure recur so frequently as to cause unsteadiness in the supply.

(5.) The standard pressure shall be fixed by the undertakers for every pair of distributing mains, and notice of the amount of such standard pressure shall be given to the County Council before the undertakers commence to supply energy to consumers through such mains, and such standard pressure shall not be altered except by permission of the County Council, and upon such terms and conditions as the County Council may impose, and after public notice has been given during a period of one month, in such manner as the County Council may require, of the intention of the undertakers to apply for permission to alter the same. The undertakers may appeal against any decision of the County Council under this regulation to the Board of Trade, whose decision shall be final.

(6.) Before commencing to give a supply of energy to any consumer, the undertakers shall declare to such consumer the constant pressure at which they propose to supply energy at his terminals. The pressure so declared at any pair of consumer's terminals shall not, except by agreement, be greater than 115 volts or less than 45 volts, if continuous, or the equivalents thereof respectively, if alternating, and shall not at any time be altered or departed from except in consequence of any authorised alteration of the corresponding standard pressure. In distribution on the three-wire system, the central terminal shall for the purposes of this regulation be considered to form a pair with either of the outer terminals, and similarly for mutiple-wire systems; and, in the case of a transformation of energy on the consumer's premises, the undertakers shall give the consumer the choice of a supply at either of two different pressures, one of which shall be approximately half the other, and in such case the pressure so chosen by the consumer shall be the declared constant pressure.

(7.) The variation of pressure at any consumer's terminals shall not under any conditions of the supply which the consumer is entitled to receive, nor at any time, exceed 4 per centum from the declared constant pressure, whether such variation be due to the resistance of the service lines or apparatus belonging to the undertakers, or to any action or effect produced by such apparatus, for which the consumer cannot be shown to be responsible, or, partly to any variation of pressure in the distributing mains from which the supply is taken.

(8.) If the undertakers make default in complying with any of

these regulations as to supply, they shall, subject to the provisions of the order, be liable to a penalty not exceeding £5 for every such default, and to a daily penalty not exceeding £5.

These regulations are made subject to the power of the Board of Trade to make such further or other regulations as they may think expedient; and nothing in these regulations shall be construed to authorise the undertakers to lay any electric line or work their undertaking otherwise than in accordance with the order and the principal Act, or to supply energy otherwise than by a system for the time being approved of by the Board of Trade under the order.

ELIMINATING THE TEMPERATURE ERROR IN VOLTMETERS.

WE read the following in *L'Electrician*:—In all voltmeters based upon electro-magnetic action, the current passing through the bobbin depends on the difference of potential to be measured, and on the resistance of this bobbin. If this resistance is increased by heating, the instrument is retarded, and if when it has been calibrated the heating caused by a given difference of potential producing a continuous current in the bobbin has been taken into account, the voltmeter can only give exact indications on condition that practically the same voltage is always maintained at the terminals. In order to remedy this inconvenience, Dr. Kahle has conceived a method of winding the bobbins of voltmeters, which renders their indications independent of the temperature. This result is obtained by winding the bobbin with two parallel wires, acting in opposite directions. The principal wire magnetises, and the secondary wire demagnetises the core of the voltmeter; but as the auxiliary wire has a greater resistance than the principal wire, the magnetising action predominates. By taking for the principal wire a metal whose coefficient of temperature is higher than that of the secondary wire, we can easily see that a rise in temperature reduces both the magnetising action of the principal circuit and the demagnetising action of the secondary circuit. In order that the resulting electromagnetic effect may remain the same, it is necessary that the difference between the ampère-turns of the two bobbins should be the same for all temperatures, a result which is obtained when the ratio of the two windings is the same as that of their coefficients of temperature.

It is evidently advantageous to employ for the principal wire a metal of low specific resistance, and for the auxiliary winding one of high specific resistance. As, however, the coefficient of temperature of good conductive metals is generally somewhat high, and that of bad conductors rather too low, the condition indicated above for establishing a system of compensation cannot be fulfilled without an accessory arrangement, which consists in establishing an external resistance, the coefficient of temperature of which is not very high, in series with the principal wire. Dr. Kahle has constructed, on these principles, voltmeters whose indications remain quite independent of the temperature.

Telephones in New York.—The Metropolitan Telephone Company of New York has the largest multiple switchboard in the world; it has a capacity of 6,000 metallic circuit subscribers, and at the present time is operating more than 3,800. The average daily number of connections made on this board is 48,238, and the average for the whole city is 103,621, about 98 per cent. of these connections being made between the hours of 8 a.m. and 6 p.m. In one station there are 128 operators, each of whom attends to between four and five hundred calls per day of 10 hours. The underground plant of the company has grown to a wonderful extent. There are in operation at the present time nearly 300 separate underground cables, each containing 50 twisted pairs of conductors, aggregating 145·5 miles of cable, or over 14,000 miles of wire. 140 of the 300 cables terminate at one office.

LONDON COUNTY COUNCIL.

THE weekly meeting was held on Tuesday last at Spring Gardens, with Sir John Lubbock in the chair.

The Highways Committee had considered a notice (Registered No. 119), dated 3rd October, 1890, of the London Electric Supply Corporation, of intention to lay distributing mains in Southwark Street, Blackfriars Road, and Borough High Street (1 plan). There appeared to be no objection to what is proposed, provided that the mains for Southwark Street be laid in the subway there. The committee recommended that the sanction of the council be given to the works referred to in the notice (Registered No. 119) of the London Electric Supply Corporation, dated 3rd October, 1890, upon condition that the company do give two days' notice to the council's engineer before commencing the works; that the mains for Southwark Street be laid and properly protected in the subway there; that the positions to be occupied by the mains in the subway be subject to the approval of the engineer of the council, and that the work of placing them be carried out to his satisfaction; that the mains in the other thoroughfares specified in the notice be laid under the footways, and be kept 9 inches below the underside of the pavement, wherever it is found practicable to do so, and that where the mains cross the carriage-ways, they be kept at the same depth below the concrete, or the road material, as the case may be; that the clerk be instructed to forward to the company a notice requiring it to lay the mains in Southwark Street, referred to in the notice dated 3rd October, 1890 (Registered No. 119), in the subway of that thoroughfare.

It was reported that during the present year testings made with the portable photometer in Bermondsey, Rotherhithe, Deptford, and Greenwich have shown the gas supplied by the South Metropolitan Gas Company in those districts to have been of deficient illuminating power. The testings, with but one exception, have shown the gas supplied to be of a less illuminating power than the company are required by their Act to supply. The nearest official testing stations to the districts in question are at Tooley Street, Peckham, and Plumstead, and it is clear that the large area between these stations is without any effectual check on the quality of the gas supplied. In these circumstances, they have directed the attention of the Gas Referees to the matter, and have requested them to prescribe an additional gas testing place in such a position as to ensure that gas supplied to the district in question is subject to official examination.

The weekly cash paper showed the following items:—

Maintenance of telephones and fire alarms ...		£1,800	0	0
Wadeson, C. A.—				
c 954 Mounting plans, &c., *re* electric lighting testing, June, 1890		4	19	11
General Capital Account (Electric Lighting Testing)—				
India-rubber, Gutta Percha, and Telegraphic Works Co.—				
B 1920 Apparatus for testing station, Cranbourne Street, Sept., 1890	£198 15 1			
Fletcher, T., & Co.—				
B 1921 Apparatus for testing station as above, June, 1890 ...	3 18 3			
		202	13	4
H.M. Postmaster-General—				
B 1969 Altering telegraphic pipes to suit new level of improvement at Mount Pleasant, Clerkenwell, June, 1890 ...		66	2	5
Subscriptions for telephonic communication ...		5	0	0
Knight, J.—				
c 1218 Gas-fittings, electric light fittings, &c., for offices, Spring Gardens, March to June, 1890		107	6	1
Sax, J. (1504)—				
c 1153 Providing electric bells, June, 1889 ...		10	13	6
Articles used for Electric Light Purposes.				
Harris, J. F. and G. (1569)—				
c 1157 Whitewood casing and cover, May, 1890		13	16	0
General Electric Co., Limited (1732)—				
c 1158 Blocks, shades, &c., March and May, 1890		6	10	0
Thompson, Ritchie and Co. (1578)—				
c 1159 Counterweight pendants and opal shades, June, 1890		9	16	6
Rashleigh Phipps and Dawson (1861)—				
c 1160 Counterweight, block, silk, and shade, May and June, 1890		3	18	10
Siemens Brothers and Co., Limited (1577)—				
c 1161 Cut-outs with bridges, June, 1890 ...		2	5	0

NOTES.

Galway Electric Lighting.—It may be of interest to our readers to know that there are being erected for the Galway Electric Company two 42-inch Hercules turbines giving from 75 to 90 H.P., with a fall of from 9 feet to 11 feet, to supply light and motive power for which there is a demand. The company has, since July 1st, been lighting the docks and other works, making use of an old flour mill machinery.

Electric Light at Stockholm.—Although detailed plans for the erection of the proposed electric central station which, like the gas works, is corporation property, have not yet been laid before the corporation, the latter has given permission to start the preparatory work, such as clearing away of old buildings from the site, &c. As usual, the estimated cost is now found to be too low, and the total expenditure will probably be nearer 2,000,000 kr. than 1,500,000 kr., the amount of the original estimate.

Electric Lighting in Nelson.—The gas committee of the Nelson local authority have received and approved the report of the gas manager upon a scheme of electric lighting for the town, and he has been instructed to get out specifications for the laying down of a cable, and other necessaries, for an installation capable of producing 600 lights. At the last meeting of the board it was stated, in answer to a question, that the price of the electric light would be double that of gas, and while the latter was 2s. 6d. per 1,000 feet, the former would be 4s. 6d. for the same amount of illumination.

Electric Lighting in Pemberton.—The members of the Pemberton (Lancashire) Local Board have expressed themselves satisfied with the electric light trials, and the chairman of the board is of opinion the adoption of the system throughout the district is only a question of time.

The Lineff Traction System.—Colonel Huber, of the well-known Oerlikon Engineering Works, last week inspected the experimental line on the Lineff system at Chiswick. Negotiations were commenced on behalf of the Oerlikon Company with a view to obtain a license from the Lineff Syndicate for various continental countries. We understand that a powerful combination is to be formed for the purpose of working the invention in France. With regard to the application of the system on the West Metropolitan tramways, we are informed that the Hammersmith Vestry has decided to grant the application, subject to a favourable report being received from an expert whom they will appoint.

Meters.—It would be interesting to ascertain how many electricity meters are in use in London. According to a recent return regarding the Geneva Central Station, 450 Aubert meters and 65 Aron meters are in operation; yet the number of incandescent lamps in daily service is only 5,375, of which 2,433 are located in the theatre and the remaining 2,942 are distributed among 216 subscribers. We wonder whether London, with all its central stations, can total 515 meters in use.

The Tudor Accumulator.—The use of Tudor accumulators in Germany has been greatly extended during the past few years. So much has this been the case that the makers, Messrs. Müller and Einbeck, of Hagen, resolved to open branch works in Austria, and the accumulator factory of Messrs. Getz and Odendall has just been acquired for that purpose.

A Long Electric Line.—An American contemporary says:—A notable installation is about to be made between Seattle and Tacoma, a distance of 42 miles. This will be the longest electric railway in the world.

The Central Institution Students.—Of the 100 odd candidates who entered at the end of September for the Matriculation Examination at the City and Guilds Central Institution 60 passed, and 16 did sufficiently well to be allowed to enter the college as unmatriculated students. In addition to the regular students of the second and third years, and the 76 above referred to, who are admitted to attend courses in *all* the four departments of mathematics and mechanics, engineering, physics and chemistry, some 20 special students have entered for portions of the advanced courses in one or more of these departments. On the result of the entrance examination the Clockworkers' Scholarship of £60 a year, with free education, tenable for two years and renewable for a third, was gained by C. E. Stamp, from St. Paul's School, and the three Institute's Scholarships, each of sufficient value to cover the students' fees for three years at the Central Institution were gained by G. H. Baillie, from Winchester House School, C. V. Drysdale from the Finsbury Technical College, and A. E. Sonneborn from Tottenham College. At the end of last session the John Samuel Scholarship, granted to a meritorious student of the Central Institution at the close of his second year's course, and consisting of £30 and free education for the third year, was awarded to C. W. Clinton; the Siemens medal, given to the students of greatest merit in the department of Electrical Engineering, was taken by R. Wightman.

Faure-Sellon-Volckmar Cells.—A well-illustrated pamphlet, which is being distributed by the *Bulletin International de l'Electricité*, has been published by the Société Française d'Accumulateurs Electriques, describing these well-known accumulators (E.P.S. type). Details are given regarding the construction of the cells, their methods of use, applications for lighting or as regulators, and to traction purposes. A perspective view is given of one of the accumulator cars now in service on the Levallois-Madeleine Tramway, which was described in the REVIEW some time ago.

Priestman's Petroleum Engines.—We learn that a gold medal for these oil engines has been awarded at the Edinburgh Exhibition.

Telephony in Scotland.—The Glasgow Committee of the Mutual Telephones Company, Limited, has decided to adopt the metallic system for Scotland, so as to enable subscribers to speak over long distances, as, for instance, between Glasgow and Manchester and London. The new system is proposed to be inaugurated with the new year.

A Runaway Electric Car.—The *Birmingham Post* of the 14th inst. says:—The passengers by the Bristol Road tram, leaving Navigation Street at 7.45 last evening had a very narrow escape. As soon as the car began descending Suffolk Street it was evident that something was wrong, and as the driver kept ringing his bell, and the speed of the tram increased, it became evident that he had lost control of it. The heavily-laden car went down the hill at a fearful pace, and threatened to upset as it passed from the double to the single line. The progress of the car was watched with intense anxiety, as the crossing at the bottom of Holloway Head is a most dangerous one. By the regulations of the company the car should be stopped at the bottom of Suffolk Street, but it was apparent that for some reason or other this was impossible, and a collision with the many vehicles about seemed all but inevitable. Fortunately, however, everything was cleared out of the way, and the tram brought to a standstill by the cabstand, very much to the relief of the occupants. What was the cause of the incident could not be gathered beyond that there was some defect or other with the brake-power. The name of the driver was taken by a police-officer, and the rest of the journey was performed under less exciting circumstances.

Telephones in Sweden.—Although the Swedish telephonic system is probably unrivalled, the Swedish engineers evidently do not mean to rest on their laurels. The Swedish Government has placed a sum of 1,600 kr. at the disposal of the State telegraphs, asking them to send a suitable man to Holland, England, and America, in order to see whether any improvement has recently been made in telephones.

Gold Medal.—Messrs. Davis and Timmins, of Hatton Garden, have been awarded a gold medal by the jurors of the Edinburgh Exhibition for general excellency of manufactures.

Literary Announcements.—Messrs. Crosby, Lockwood & Co. announce a fourth edition of "Electric Light: Its Production and Use," by J. W. Urquhart.

City and South London Railway.—The *Financial News* says some of the shareholders in the City and South of London Railway are beginning to ask when their underground electric railway from King William Street to Stockwell will be inaugurated. The chairman of the company has frequently assured them that the line "is expected to be opened shortly," and that most of the machinery and rolling stock is already to be found at the Stockwell depôt. A visit will, however, convince anyone that the railway and plant are not in such a forward condition as would appear from the chairman's statements. As over £650,000 has already been sunk in the undertaking during the past four years, it is quite time the railway was opened.

Copper.—Production of copper ore from the mines of the Canadian Copper Company, Sudbury, Ont., for the last year is officially stated to be 60,000 tons. Copper shares are not in a good position, according to the dealings on the French Bourse. The feeling of speculators is that copper shares are going lower.

The New Cables between Peru and Chili.—As foreshadowed in our "Notes" of last week, the cable steamer *Silvertown* left Greenhithe, on October 11th, for the West Coast of South America. On the preceding day a large company of guests were invited to luncheon on board, to bid farewell to their friends, and to wish the expedition God-speed. The ship takes out about 1,750 nautical miles of submarine telegraph cable, weighing about 2,700 tons, and the total cargo carried, including coal, cable, provisions, and general stores, weighs somewhat under 5,000 tons, a comparatively light burden for this vessel, whose capacity is nearly 7,000 tons. The cable was manufactured by the Silvertown Company for the Central and South American Telegraph Company, and is to be laid from Chorillos, near Lima, Peru, to Yquique, the well-known nitrate port, and thence to Valparaiso, the principal port of Chili. More direct and rapid communication than now exists will be thus secured between the points mentioned, since the present cables owned by the West Coast of America Telegraph Company, and laid in 1875, touch at many intermediate places along the coast between Lima and Valparaiso. The Central and South American Company, by means of their cables from Lima northwards along the West Coasts of South and Central America, their land line across the isthmus of Tehuantepec, and their cables across the Gulf of Mexico, will, on completion of the new lines, have communication over their own systems from Valparaiso to the United States. The total complement of persons on board amounts to 144, roughly divided into: Staff, officers, and engineers, 23; cable hands, 40; crew, stewards, &c., 59; stokers, firemen, &c., 22. The expedition is under the direction of Mr. M. H. Gray, engineer-in-chief, and Mr. J. R. France accompanies the ship as representative of the Central and South American Telegraph Company. The trip is expected to last between five and six months, including voyages out and home (about 9,000 miles each way), sounding work, cable laying, term of guarantee, and possible delays. We wish the expedition every success.

Vestries and Electric Mains.—Major C. B. Waller, the manager and secretary of the London Electric Supply Corporation, was summoned by the Vestry of St. George the Martyr, Southwark, on Wednesday, for that "he did cut away and take out part of a sewer in Union Street, Borough, for the purpose of laying mains for electric lighting without first having obtained the permission of the vestry." The surveyor of the vestry discovered a week or so since that the Corporation had cut away a portion of a sewer for the purpose of carrying their mains over it. For the defendant it was urged that the vestry had no power to interfere, and in the end Mr. Slade adjourned the summons to give both parties an opportunity of referring the matter to the Board of Trade.

The Popularity of Electrotechnics.—The total number of students receiving electrical instruction in the Finsbury Technical College (day and evening) to date, this session, is 595, of whom 444 attend laboratory work. If similar Institutes are filled in a like proportion we shall soon have that old question of "What shall we do with our boys" raised again."

Removal.—Mr. Carl Oppermann informs us that he has removed his business from 41, Sigdon Road, Hackney, to 2, Wynatt Street, Clerkenwell, E.C.

Business Mention.—Messrs. O. Berend & Co. have shown us some really good designs in electroliers in bronze and majolica; in fact, more tasteful specimens we never saw. The price is said to be very moderate.

The Pacific Cable.—We extract the following from the *Evening News* of October 11th: "Sir John Pender, the 'Cable King,' has arranged to pay a visit to the Pacific side of the world next year, and he has already apprised Mr. Sandford Fleming, the Austral-Canadian cable enthusiast, that he will then be prepared to discuss the feasibility of establishing cable-graphic communication between Vancouver and the Antipodes. It is evident from this that Sir John and his colleagues have come round to the point of recognising the necessity for an alternative cable to Australia by way of the Pacific. The fact of the whole matter is, that the Eastern Telegraph Company, true to the national instinct of self-preservation, have realised that if their monopoly of the cable business is to be maintained, they must step in and lay the Pacific cable. The last total interruption of the whole of their cables between here and Australia had the effect of producing a strong feeling in the colonies in favour of the long talked of Pacific cable as an alternative line in case of a recurrence of such accidents, and there can be no doubt that if Sir John Pender and his friends display any tardiness in taking the matter up, somebody else will do the work before long.

Running Alternators Parallel.—At a late hour we have received a very interesting letter on this subject from Mr. Hooker, electrician to the Bath Electric Light Works, who has been running Mordey alternators in parallel in a most satisfactory manner. As a drawing accompanies his communication, we must reserve it till next week.

Sales of Electrical Plant, &c.—It will be noticed in our business columns that a stock of "Lever" arc lamps and the patent rights for England and abroad are offered for sale. The electrical plant used for lighting the House of Commons is also to be put up to public auction.

To A. E. M.—The patent specification in which the form of magnet used in the Gower-Bell telephone receiver is first described, is No. 315, dated 25th January, 1879, and it does not appear that any claim is made in the same for the particular form of magnet and coils used; on the expiry, therefore, of the Bell patent in December, this form of magnet for telephonic purposes becomes public property, though probably this might be contested by the owners of the patent.

Edinburgh International Exhibition.—The Royal Scottish Society of Arts held a special session at the Exhibition on October 13th, under the presidency of Lord Kingsburgh. Five papers were read, three of which were electrical, viz., "On the Telegraphic Exhibits," by Prof. Grant-Ogilvie; "Telpherage and Electric Railways," by Mr. E. Manville; and "Electrical Navigation," by Mr. A. R. Bennett. There was a large attendance of members. In moving a vote of thanks to the authors, Lord Kingsburgh regretted that the electrical industries had, so far, met with scant recognition in Scotland, and expressed a hope that the abundant water supplies in the Highlands would soon be turned to useful account in providing light and power to the various cities and towns. The members afterwards took trips on the telpherway and electric tramway and in the electric launches; and a special vote of thanks was accorded to Mr. Bennett, to whose invitation the meeting had been due.

Steam Pipe Covering.—Messrs. A. Haacke & Co. have received a silver medal at the Edinburgh Exhibition, where they covered the main steam pipes with their pyrostat composition. This is a non-conducting composition, and can be applied even to red-hot surfaces, and is specially adapted for covering boilers and steam pipes containing 150 to 200 lbs. pressure.

Electric Lighting.—The Town Council of Paisley have agreed to apply to the Board of Trade for a provisional order to supply electric lighting for private and public purposes within the burgh.

Pictorial.—It is not often our lot to view a combination of things electrical and pictorial; indeed it is generally considered that machinery of any description absolutely refuses to lend itself to any effort of a picturesque nature; but a day or two since we were invited to view a portrait of Mr. Thomas Parker, of Wolverhampton, and promptly responded in person to the invitation. On arriving at the studio of the artist, Mr. E. Goodwyn Lewis, at No. 17, Fitzroy Street, we were surprised to find a fine painting representing not only Mr. Parker but that gentleman surrounded by machinery and electrical instruments, as if in the works at Wolverhampton. Through an open window is well shown and judiciously treated a tram-car, and the electric light is freely displayed, the whole being painted as illuminated by that light. It is an important work, bristling with difficulties, which the artist must be credited with having overcome in a remarkable degree. We may add that the work has been executed for Mr. Oddie, of Ballarat, Australia, who intends presenting it to the Ballarat Art Gallery, art and electricity both being among the donor's favourite pursuits.

Submarine Telephonic Communication.—The German Post Office officials have been experimenting during the last few days with the North Sea cable, 75 kilometres long, between Heligoland and Cuxhaven, to test the possibility of using submarine cables of con siderable length for telephonic purposes. The results have been very favourable, distinct communication having been obtained at both ends.

Personal.—Mr. Oswald Haes, who is an old student of Finsbury Technical College, and has been on the engineer's staff of the Brush Electrical Engineering Company and its predecessor, the Anglo-American Company, for three years, has been appointed to the management of the engineering department of the company's branch in Australia, and is shortly proceeding to Sydney, N.S.W., to take up his position.

Electric Lighting for Lewes.—At a largely-attended meeting of Lewes ratepayers, held on Wednesday night, under the presidency of the Mayor, it was decided by an overwhelming majority to adopt electricity for street lighting.

Business Extensions.—Messrs. Paterson and Cooper inform us that they have opened a West-end showroom at 3, Prince's Mansions, Victoria Street, Westminster, where it is proposed to keep samples of manufactures.

The Eight Hours Bill.—Mr. R. W. M'Leod Fullerton, Unionist candidate for the East Division of Edinburgh, addressing the electors, said he supported the right of the individual to freedom of action and making of contracts; but to the general principle he would make exceptions, such as in cases where there was a temptation both to employers and employed, or to either, to make agreements which were prejudicial to the health and comfort of the workman. He pointed to the case of the telegraph offices in large towns, where seven hours' work a day was as much as the telegraph clerks could stand. He would be in favour of a commission of inquiry as to the amount of work in the various telegraph offices in the country, with the view of determining in what offices a compulsory seven hours day should be fixed.

Electrolysis versus Paracentesis in Ovarian Cysts.—Dr. Sigmund Cserey, writing in a Hungarian medical journal, points out the great advantage that electrolysis possesses over paracentesis in ovarian cysts where more radical operative measures are for any cause inadmissible. The enormous loss of albumen by tapping is frequently followed by serious weakening of the patient, which is not the case where electrolysis is employed, this method causing the proteid to be partially reabsorbed by the system. He mentions a case where an ovarian cyst had been tapped twelve years previously, but had very soon filled again. Since then electrolysis had been several times employed with far more lasting results. He used a 20-cell Smee's battery, the anode being a needle, which was inserted into the abdomen to the depth of 3 inches and a half, and the cathode, a large flat surface, applied to the lower part of the back. The circuit was opened with two cells, and gradually raised to 14, which caused so severe a burning pain that the number was reduced. The whole sitting lasted 35 minutes. The good effects were soon seen in the increase of the urine and the decrease of the circumference of the abdomen.

A Novel Use for the Electric Motor.—The convenience of the electric motor is being shown to crowds who watch the Sioux City Corn Palace, now in course of construction. About 15,000 bushels of corn are used to decorate the building. Last year the saws to split the corn were run by four horses, and the irregular speed caused much annoyance. This year a 3 H.P. Hawkeye electric motor belted direct to a saw does all the work much more satisfactorily, one man sawing about 60 bushels an hour, to supply over 200 men and about the same number of women, who are decorating the building. For working at night the immense structure is illuminated by 50 arc lights and over 1,000 incandescents.

NEW COMPANIES REGISTERED.

Henry Leggott & Co. Limited.—Capital, £20,000 in £10 shares. Objects: To trade as electrical engineers, iron and brass founders, and to take over the business of Henry Leggott and Co., ironmongers, domestic, sanitary and gas engineers. Signatories (with 1 share each):—*J. R. Cordingley; E. Greaves; J. L. Wilson; *J. R. Birkinshald and J. J. Colefax, all of Bradford; *Hy. Leggott, Hepperholme; *R. Leggott, Harrogate. The signatories denoted by an asterisk are the first directors. Qualification £500 in shares or stock, remuneration £1 1s. each for every meeting attended. Registered 7th inst by R. Jordan, 120, Chancery Lane. Registered office, 73, Market Street, Bradford.

Cape Town and District Gas Light and Coke Company, Limited.—Capital, £100,000 in £10 shares. Objects: To purchase the gas works of the Cape Town Gas Light Company, Limited, and to carry on the business of the same. To carry on the Cape Town and its districts, and in South Africa, England and elsewhere, the business of an electric lighting and power company in all branches, including the manufacture, sale, and supply of electricity for light, motive power, and other purposes. Signatories: *R. A. Fairclough, 14, Bunhill Row; *J. Boustead, 34, Craven Street; *H. R. Savory, 11 & 12, Cornhill, 100 shares each; Wm. Lewis, D. Sluter, F. H. Leslie, J. A. Kelman, all of 251, Winchester House, 5 shares each. The first directors are the signatories devoted by an asterisk, and the Hon. Hy. Noel. Qualification, £1,000 in shares. Remuneration, £1,200 per annum divisible. Registered 9th inst. by Paine, Son & Pollock, 14, St. Helen's Place.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

International Okonite Company, Limited.—An agreement of 18th July between Woodhouse and Rawson United, Limited (the vendors) and this company, cites that by an agreement of 24th June it was agreed that the vendors should sell to the company the business and properties therein described for £324,990, of which £113,330 was to be payable by the allotment of fully paid preference and ordinary shares, the amount of such shares respectively to be fixed by the vendors, provided that not less than £50,000 of either description be allotted. Under the present agreement the vendors fix the amount to be allotted in preference shares at £61,160, and the amount to be allotted in fully paid ordinary shares at £52,170.

An agreement of 30th July between the same parties provides that the proportion of the purchase money payable in shares shall be £113,320 instead of £113,330, and payable £56,660 in fully paid preference shares and £56,660 in fully paid ordinary shares.

Mulholland, Maugham and Company, Limited (mechanical and electrical engineers).—An agreement of 14th August, filed 27th ult., relates to the purchase by the company of the Mulholland, Maughan & Co., of West Carnforth, Durham, the consideration being the allotment of 120 fully paid £10 founders' shares, which will be entitled to one-half the surplus net profits remaining after payment of 7½ per cent. per annum dividend upon all the shares.

Northern Counties Electric Light and Power Supply, Limited.—The registered office of this company is situate at 13, Victoria Street, Westminster.

Grange Syndicate, Limited (Groth's Electric Tanning System).—The registered office of this company is situate at 3, Tokenhouse Buildings, Bank, E.C.

Weston House-to-House Electricity Supply, Limited.—The registered office of this company is at 13, John Street, Bristol.

Paddington and Bayswater Electric Light and Power Supply, Limited.—The registered office of this company is situate at 13, Victoria Street, Westminster.

CITY NOTES, REPORTS, MEETINGS, &c.

Woodhouse and Rawson United, Limited.

AT the general meeting of the shareholders, held at Winchester House, on Friday, the 10th, Lord Aberdare presided, and in moving the adoption of the report and accounts, said: There were two points in the former to which he desired to call attention. The first was that the ordinary shares, of which one-half remained uncalled, were those that were taken by the public; the shares allotted to the vendors, and which of course were fully paid, stood in the balance sheet. As regards the other point, the report mentioned that the Sociedad Española de Electricidad, in Barcelona, had placed the whole of its arrangements for improving and extending the lighting of that city by electricity in the hands of the company. The contract had been made with Woodhouse and Rawson, Limited, and it had been taken over by the present company, and at the present time the Barcelona Society was engaged in carrying out the company's suggestions. A board of directors might present its report in two ways: it might present the report and resolutions in the briefest and most succinct form, leaving it to the Chairman to supply any special facts and explanations which might be called for; or the report might take the form of a detailed account of the company and its development and its prospects for the future. The directors of Woodhouse and Rawson United, Limited, had chosen to take the latter course, which has the further advantage that it relieved the the chairman from making a very long speech. Those who had carefully studied the report would see how numerous and important the operations had been. To some they might seem incongruous, but a little reflection would show that in reality there was a close connection between them. The manufacturing, supply and contract departments explained themselves. The development of the business, the taking over and bringing out of new inventions by the purchase of patents or of manufacturing under royalties to inventors formed a large and lucrative portion of the business, as also did that portion of the business which consisted in aiding in the formation of companies which require capital beyond their means, and experience which they did not possess. All these branches of electrical business were undertaken by the several companies purchased by and absorbed into this company. They had in their various departments been extended as rapidly as the short period of the company's existence permitted. The manufacturing, supply and contract departments had made considerable improvement in actual performance, and gave what the speaker ventured to call a well-grounded promise of further extension. Altogether the report presented a picture of great activity which, with time and opportunity, could be greatly extended. In his opinion to the three branches, manufacture, supply and contract, was due the solid basis upon which the ultimate success of the company should rest. Obviously expectations of large profits from those sources could only be gradually realised. They must sow before they could reap. It would be unusual and, he thought, inadvisable to enter minutely into the source of profits in the case of a manufacturing company like this. But this much he might say: the large profits of the present year had enabled the directors to recommend a dividend of 15 per cent. per annum without availing themselves of the £75,000 deposited by Woodhouse and Rawson, Limited, to guarantee that amount of dividend for three years, had enabled the directors to place £25,000 to the reserve fund, to carry forward over £16,000 to next year's accounts, and to write off £7,421 against the estimated value of the patents. These large profits had been mainly derived from the fourth branch of the company's business, viz., the testing and approving of new patents and inventions connected with electrical and engineering science, and their introduction to the public either by making arrangements for working them, or by assisting the owners and inventors in forming separate companies for that purpose. Such were the operations of Woodhouse and Rawson, Limited, in introducing the Elmore process, which the present company was, with every prospect of success, extending over the chief commercial centres of Europe; the International Oknonite Company, the West Kensington Co-operation Stores, &c. That there was a certain risk involved in the introduction of new inventions it would be absurd to deny, but he could honestly say that the operations referred to had never been undertaken without the most careful enquiry that the judgment, experience and knowledge of firms possessed by the board had been able to exercise. They represented, in fact, a very small proportion of the proposals made for the board's assistance in one form or another, the vast majority of which had been rejected, because the board limited itself to the selection of such as seemed thoroughly sound and of intrinsic value. It was a mere act of justice to the managing director, Mr. F. L. Rawson, to say that the success hitherto attained had been mainly owing to his initiative, and the extreme energy and ability he had displayed. Neither could the speaker refrain from expressing his personal sense of gratitude to their vice-chairman, Sir Rawson W. Rawson, for his great exertions and the unlimited attention to the affairs of the company, especially during the period of severe illness which he, the speaker, had undergone. To his others colleagues, also, he tendered his grateful acknowledgments. The report spoke in by no means exaggerated terms of the unusual demands which had been made upon the time of the staff, owing to the pressure involved in a new company engaged in such extensive operations, and the speaker begged to add his own acknowledgments of the way in which the staff had performed its duties, and to warmly recommend the adoption of the resolution for the formation of an *employés* pension fund. Might he be permitted to make some suggestions which were the fruit of past years' experience. First, he thought it very desirable that the company's capital should be increased, and he trusted that the board would ere long submit resolutions with that object. The report told them that the directors had already considerably extended the business and the business premises of the company, but he must tell them that these extensions could not be fully developed nor made as profitable as they might without an addition to the working capital. At present

they had the use of the £75,000 deposited with them by Woodhouse and Rawson, Limited, but that would have to be repaid two years hence at the latest. It might be worth while to do so earlier, if satisfactory arrangements could be made with the liquidators, to whom doubtless it would be of great advantage also. That was a matter for the future; still he thought it advisable to prepare the shareholders for possible proposals in that direction. His other suggestions related to an increase in the numbers of the board and working staff. He had already referred to the heavy responsibilities which had rested upon the board, which consisted, he might say, of seven only during the past year, in the conduct of the company's general business, and in sifting the various schemes brought before them, and he need not enlarge further upon that point. Such a business could not be properly carried on without great expenditure of time and labour, and long and frequent discussion. He saw little probability of a diminution of the directors' work in the near future, and he did not think that the present pressure upon them could long be continued, or that it ought to be. He would, therefore, venture to suggest the increase of the board to nine, the full number authorised by the articles of association, and that the directors' remuneration also should be increased by the allowance of a percentage on the net profits of the year. The present remuneration was inadequate to gentlemen who are obliged to give so large a part of their time to the superintendence of this great and growing business. As regards the working staff, with the best will in the world the board of directors could be little more than a consultative body; the initiative, no less than the details of the company's operations, must rest with the executive staff. Theirs was an excellent one so far as it went, but no man ought to be called upon to do all the work which at present fell upon many of the company's officers, and more especially upon the managing director. There ought to be some further division of labour, the cost of which would be inconsiderable as compared with the increased efficiency in the external and internal management. It only remained to thank the meeting for the patience with which they had listened to his remarks, to echo the congratulations of the report upon the company's achievements in the past year, and its present position and prospects, and to express the earnest hope that the shareholders would with a unanimous vote support the board in its efforts to give stability to an enterprise which had begun so well. He trusted the reasons given in the report for his resignation would be thought sufficient, and he congratulated the shareholders on the new director proposed for their acceptance. The high character of Sir Edward Thornton for ability and honour in his past career as a foreign minister was well known, and he hoped they would re-elect Sir Rawson Rawson as a director. It was the board's intention to request Sir Rawson Rawson to assume the chairmanship, and he need not say that he entirely concurred in the choice made. In conclusion, he was happy to announce that the affairs of the Woodhouse and Rawson Company, Limited, might now be considered as settled, after long and vexatious endeavours to bring that settlement to an earlier conclusion, and he was happy to hear that the shares were already on their way to the various long-expectant shareholders.

Sir Rawson Rawson seconded the motion. He said invention in the present day in connection with electricity was advancing so rapidly, that it only required energy and prudence on the company's part to ensure numerous offers of most valuable inventions. They had now in course of examination and testing some exceedingly valuable patents.

A Shareholder noticed in the balance sheet that the number of ordinary and of fully paid shares issued amounted to 34,633, whereas on January 29th the company issued a statement to the effect that 36,316 had been issued. He would like to know, also, whether £31,000 was not an unusual amount of cash to keep in hand.

Mr. F. L. Rawson, with regard to the first question, said the shareholders might be assured that whatever statements had been made they were absolutely correct. As regards the other point, the explanation was that a cheque for £30,000 had not yet been paid into the bank when the balance sheet was made up, but was paid immediately afterwards.

Another Shareholder pointed out that that some of the vendors' shares had not yet been allotted.

The Chairman said they had now been allotted. The delay was owing to the directors having had to wait for the liquidator's instructions of Woodhouse and Rawson, Limited.

Another Shareholder asked what proportion of the £91,000 and odd put down as profit was *bonâ fide* trade earnings?

The Chairman declined to enter into questions of that kind. It was not, he considered, in the interests of the company to give these explanations, although the questions occurred very naturally to the shareholders.

Mr. F. L. Rawson, replying to another shareholder, said that he expected that the Stock Exchange would grant the company a quotation in about a week's time.

The resolution was agreed to.

The Chairman then moved to declare dividends at the rate of 7½ per cent. and 4 per cent. on the preference shares, making, with the interim dividend of 7½ per cent. already paid upon the ordinary shares, and 4 per cent. already paid upon the preference shares a dividend of 15 per cent. per annum on the ordinary and of 8 per cent. per annum on the preference shares. He observed that the 7 per cent. preference shares were entitled to an extra 1 per cent. each year that the ordinary shareholders received 10 per cent. per annum.

Sir Rawson W. Rawson was re-elected a director, and Sir Edward Thornton was elected a director in the place of Lord Aberdare. Messrs. Pixley & Co. were reappointed auditors at a remuneration of 100 guineas.

A resolution to increase the directors remuneration from 30th June, 1890, by a commission of 2 per cent. on the net profits of the company was agreed to unanimously.

Mr. Pope, Q.C., one of the directors, in the course of a few remarks said it might interest some shareholders to know that Mr. Philip Rawson, one of the directors, was in no way related to Sir Rawson Rawson. As representing the general body of the shareholders he, Mr. Pope, would jealously watch anything like a family party administration in a concern of this magnitude, and from his continuing to hold his place on the board, the shareholders might be satisfied that no such disposition had been manifested. After praising Sir Rawson Rawson's self-sacrifice and attention to the company's affairs, and expressing regret at Lord Aberdare's retirement, he went on to say that, of course, no one would imagine that £91,000 a year profit was one that could be made by the manufacture and supply of electrical apparatus. As one connected with other electrical companies, he knew pretty nearly the scale of profit to be made in such businesses. It would not be desirable to disclose to competitors the exact amount of profits the company made. It they were very large, it would provoke competition; if small, it would disclose an unfortunate state of affairs. The shareholders might be well content with what had been placed to their credit, without being very anxious to enquire into the particular source of profit. But he strongly advised them to see at all times that the profits were real. They must be well content that they were receiving 15 per cent. upon money which had only been invested for about twelve months. He advocated the maintenance of a strong reserve against contingencies. A business like this was, after all, not so steady as an ordinary trading concern; it must be more or less speculative. Since the balance sheet was made the company's profits had not fallen off. To Mr. F. L. Rawson was due the remarkable energy, and to Lord Aberdare and Sir Rawson Rawson the prudence with which the companies affairs had been conducted.

Mr. F. Rawson spoke of the *employés* pension fund as an inducement to *employés* to remain in the company's service, and said that probably the shareholders would be asked at a general meeting to sanction the scheme. With a vote of thanks to the board, and to Lord Aberdare in particular, the proceedings terminated.

The Brazilian Submarine Telegraph Company, Limited.

THE report of the directors and the accounts for the half-year ended 30th June, 1890, to be submitted to the 34th ordinary general meeting, 22nd October, 1890, states that:—

The directors submit the annexed accounts and balance-sheet for the half-year ended 30th June, 1890.

The revenue for this period amounted to £121,873 19s. 9d., and the working expenses to £16,492 5s. 3d. After providing £12,880 for debenture interest and sinking funds, and £1,559 17s. 1d. for income tax, there remains a balance of £90,941 17s. 5d.; to this is added £9,975 0s. 8d. brought forward from 31st December last, making a total of £100,916 18s. 1d. A quarterly interim dividend amounting to £19,500 has been paid, and £40,000 transferred to the reserve fund, increasing that fund to £352,626 2s. 11d.

The directors now recommend the declaration of a final dividend of 3s. per share, making with the interim dividends, a total dividend of 6 per cent. for the year, and also the payment of a bonus of 3s. per share, both free of income tax, which together will amount to £39,000, being a distribution in the aggregate of 7½ per cent. for the year ended 30th June, 1890, leaving a balance of £2,416 18s. 1d. to be carried forward. The dividend and bonus will be payable on the 23rd instant.

On the 31st July last the sum of £15,300 was transferred to pay off the 153 bonds of the 1884 issue, drawn for redemption in April last. This repayment reduces the debenture debt to £144,200.

The receipts for the half-year include the sum of £1,500 dividend to 31st December, 1889, on the company's shares in the African Direct Telegraph Company, Limited.

The various sections of the company's line are in good working order.

Sir James Anderson and Mr. Frederick Youle retire by rotation at this meeting, and being eligible for re-election as directors offer themselves accordingly.

The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

The Direct United States Cable Company, Limited.—The board has resolved upon the payment of an interim dividend at the rate of 3½ per cent. per annum, for the quarter ending 30th September, 1890.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending October 10th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,121.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (October 9.)	Closing Quotation. (October 16).	Business done during week ending October 16, 1890. Highest.	Lowest.
£						
250,000	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101	99	...
1,549,160	Anglo-American Telegraph, Limited	Stock	50½— 51½	49½— 50½xd	49½	...
2,725,420	Do. do. 6 p. c. Preferred	Stock	87 — 88	85 — 86 xd	86⅜	85⅛
2,725,420	Do. do. Deferred	Stock	14¼— 14⅜	13⅜— 14¼	14⅜	13¼
130,000	Brazilian Submarine Telegraph, Limited	10	11¾— 12¼	11¾— 12⅛	12¼	11⅞
99,000	Do. do. 5 p. c. Bonds...	100	100 —102	100 —102	100	...
75,000	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	103 —107	103 —107		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1¼— 2	1¼— 1⅝		
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1⅝— 1⅞	1¼— 2		
$7,216,000	Commercial Cable, Capital Stock	$100	102 —104	102 —104	103½	...
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	⅜ — ⅝	⅜ — ⅝		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5½— 5¾	5½— 5¾		
16,000	Cuba Telegraph, Limited	10	11⅛— 12⅛	11⅛— 12	11⅜	...
6,000	Do. do. 10 p. c. Preference	10	17 — 18	17 — 18		
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	4 — 4¼	3¾— 4¼xd	4	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10		
60,710	Direct United States Cable, Limited, 1877	20	10⅜— 10⅝	10⅜— 10⅝	10⅝	10 7/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14 — 14¼	13¾— 14⅛xd	14 3/16	13 7/16
70,000	Do. 6 p. c. Preference	10	15 — 15½	14¾— 15½	15 7/16	...
200,000	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109	107	...
1,200,000	Do. 4 p. c. Mortgage Debenture Stock	Stock	104 —107	104 —107	106½	...
£250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	14⅛— 14⅜	14 — 14¼xd	14¼	14
320,000	Do. 6 p. c. Debentures, repay. February, 1891	100	100 —102	100 —102		
446,100	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. ...	100	102 —105	102 —105		
12,500	Do. 5 p. c. Debentures, 1890, redeem. ann. drawings ...	100	102 —105	102 —105	102½	...
367,900	Eastern and South African Tel., Ltd., 5 p. c. Mort. Deb., 1900...	100	101 —104	101 —104	103⅞	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7⅜— 8⅛	7⅛— 8	7⅞	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4⅜— 5⅛	4⅜— 5⅛		
46,700	Elmore's Patent Copper Depositing, Ltd., Nos. 23,001 to 70,000	2	5 — 5⅛	5 — 5⅛	5⅛	4 15/16
67,385	Elmore's Wire Manufacturing, Limited, Nos. 1 to 67,385 issued at 1 pm. all paid (£1½ paid)	2	2¼— 2⅜	2 — 2⅛		
19,700	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£3 only paid)	5	2¼— 3	3¼— 4		
180,227	Globe Telegraph and Trust, Limited	10	8⅛— 9⅛	8⅛— 9⅛	8 13/16	8¾
180,042	Do. do. 6 p. c. Preference	10	14⅜— 15	14⅜— 15	15	14 11/16
150,000	Great Northern Tel. Company of Copenhagen	10	15⅜— 16⅛	15⅜— 16⅛	16⅛	15⅝
15,000	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	101 —104	101 —104		
230,000	Do. do. do. (issue of 1883) ...	100	104 —107	104 —107	104	...
9,334	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11¼— 12¼	11¼— 12¼		
5,334	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11¼— 12¼	11¼— 12¼		
41,600	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18 — 19	18½— 19½		
200,000	Do. do. 4½ p. c. Deb., 1896...	100	102 —104	100 —102 xd		
17,000	Indo-European Telegraph, Limited...	25	36 — 38	36 — 38		
38,348	London Platino-Brazilian Telegraph, Limited	10	6⅞— 7⅛	6⅞— 7⅛		
100,000	Do. do. do. 6 p. c. Debentures ...	100	105 —108	105 —108		
49,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 ...	10	5⅛— 6⅛	5⅛— 6	5⅛	...
436,700	National Telephone, Limited, Nos. 1 to 436,700	5	4⅜— 4⅝	4⅜— 4⅝	4 11/16	4⅜
15,000	Do. 6 p. c. Cum. 1st Preference	10	12¼— 12¾	12¼— 12¾		
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	10 — 10½	9½— 10½		
£220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ⅜	⅛— ⅜		
9,000	Reuter's, Limited	8	8¼— 8¾	8¼— 8¾x		
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ...	⅛— ...		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3¼ only paid)	5	2½— 3	2½— 3		
3,381	Submarine Cables Trust	Cert.	113 —117	113 —117		
78,949	Swan United Electric Light, Limited ... (£3½ only paid)	5	5½— 5¾	5½— 5¾	5½	5¼
37,350	Telegraph Construction and Maintenance, Limited	12	43 — 45	43 — 45	44½	...
150,000	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102		
55,000	United River Plate Telephone, Limited	5	3⅝— 4	3⅝— 4		
146,000	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 94	90 — 94		
100,000	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8⅛— 9⅛		
300,000	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101	99	...
30,000	West Coast of America Telegraph, Limited	10	4¼— 5	4¼— 5		
150,000	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	102 —107	102 —107	103½	...
64,572	Western and Brazilian Telegraph, Limited	15	11½— 11¾	11½— 11¾	11⅝	...
26,986	Do. do. do. 5 p. c. Cum. Preferred	7½	6⅞— 7⅛	6¾— 7⅛	6 15/16	...
26,986	Do. do. do. 5 p. c. Deferred	7½	4⅜— 5¼	4⅜— 5¼	4 15/16	4⅞
200,000	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106		
250,000	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
88,321	West India and Panama Telegraph, Limited	10	2⅞— 3⅛	2⅞— 3⅛	2 15/16	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12		
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	14 — 15	14 — 15		
1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	122 —127	122 —127		
179,300	Do. do. 6 p. c. Sterling Bonds	100	99 —103	99 —103		
42,853	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£3 only paid)	5	1½— 1⅝	2½— 3		

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7⅛—7⅜.—Elmore Copper Depositing Priorities, 7 —7½.—Elmore's French Patent Copper Depositing shares of £2 (issued at 10s. premium, 15s. paid), 1¼—1½.—House-to-House Company (£5 paid), 5 —5½.—International Okonite, Ordinary of £10 (£7 paid), 6½—7½.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅜—2½.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.

BANK RATE OF DISCOUNT.—5 per cent. (25th September 1890).

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page 439.*)

Now the law of traction being in that way established, one at once begins to get some light upon the subject of the design of electro-magnets. Indeed, without going into any mathematics, Joule had foreseen this when he in some instinctive sort of way seemed to consider that the proper way to regard an electro-magnet for the purpose of traction was to think how many square inches of contact surface it had. He found that he could magnetise iron up until it pulled with a force of 175 lbs. to the square inch, and he doubted whether a traction as great as 200 lbs. per square inch could be obtained.

In the following table Joule's results (see Table I.) are recalculated, and the values of B deduced:—

TABLE VII.—JOULE'S RESULTS RE-CALCULATED.

Description of electro-magnet.	Section.		Load.		Lbs. per sq. in.	Kilos. per sq. cm.	B	Ratio of load to weight.
	sq. in.	sq. cm.	lbs.	kilos.				
Joule's own electro-magnets No. 1	10	64·5	200·0	947	104·5	7·35	13,600	139
Joule's own electro-magnets No. 2	0·196	1·26	49	22	125	8·75	14,700	324
Joule's own electro-magnets No. 3	0·0436	6·28	12	5·4	137·5	9·75	15,410	1,286
Joule's own electro-magnets No. 4	0·0012	0·0077	0·202	0·09	81	5·7	11,830	2,384
Nesbit's	4·5	29·1	142·8	647	158·5	11·2	16,550	28
Henry's	3·94	25·3	750	346	95	6·7	12,820	36
Sturgeon's	0·196	1·26	53	22·6	127·5	8·95	14,850	114

I will now return to the data on Table VI., and will ask you to compare the last column with the first. Here are the various values of B, that is to say, the amounts of magnetisation you get into the iron. You cannot conveniently crowd more than 20,000 magnetic lines to the square centimetre of the best iron, and, as a reference to the curves of magnetisation shows, it is not expedient in the practical design of electro-magnets to attempt, except in extraordinary cases, to crowd more than about 16,000 magnetic lines into the square centimetre. The simple reason is this, that if you are working up the magnetic force, say from 0 up to 50, a magnetising force of 50 applied to good wrought iron, will give you only 16,000 lines to the square centimetre, and the permeability by that time has fallen to about 320. If you try to force the magnetisation any further, you find that you have to pay for it so greatly. If you want to force another 1,000 lines through the square centimetre, to go from 16,000 to 17,000, you have to add on an enormous magnetising force; you have to double the whole force from that point to get another 1,000 lines added. Obviously it would be much better to take a larger piece of iron and not to magnetise it too highly—to take a piece a quarter as large again, and to magnetise that less forcibly. It does not therefore pay to go much above 16,000 lines to a square centimetre—that is to say, expressing it in terms of the law of traction, and the lbs. per square inch, it does not pay to design your electro-magnet so that it shall have to carry more than about 150 lbs. to the square inch. This shall be our practical rule: let us at once take an example. If you want to design an electro-magnet to carry a load of one ton, divide the ton, or 2,240 lbs., by 150, and that gives the requisite number of square inches of wrought iron, namely, 14·92, or say 15. Of course, one would work with a horse-shoe shaped magnet, or something equivalent—something with a return circuit—and calculate out the requisite cross-section, so that the total area exposed might be sufficient to carry the given load at 150 lbs. to the square inch. And, as a horse-shoe magnet has two poles, the cross-section of the bar of which it is made must be 7½ square inches. If of round iron, it must be about 3½ inches in diameter; if of square iron, it must be 2¾ inch each way.

That settles the size of the iron, but not the length. Now the length of the iron, if one only considers the law of the magnetic circuit, ought to be as short as it can possibly be made. Reflect for what purpose we are designing. The design of an electro-magnet is to be considered, as every design ought to be, with a view to the ultimate purpose to be served by that which you are designing. The present purpose is the actual sticking on of the magnet to a heavy weight, not acting on another magnet at a distance, not pulling at an armature separated from it by a thick layer of air; we are dealing with traction in contact. The question is—how long a piece of iron shall we need to bend over? The answer is—take length enough, and no more than enough, to permit of room for winding on the necessary quantity of wire to carry the current which will give the requisite magnetising power. But this latter we do not yet know; it has to be calculated out by the law of the magnetic circuit. That is to say, we must calculate the magnetic flux, and the magnetic reluctance as best we can; then from these calculate the ampère-turns of current; and from this calculate the needful quantity of copper wire, so arriving finally at the proper length of the iron core. It is obvious the cross-section being given, and the value of B, being prescribed, that settles the whole number of magnetic lines, N, that will go through the section. It is self-evident that length adds to the magnetic reluctance, and, therefore, the longer the length is, the greater have to be the number of ampère-turns of circulation of the current; while the less the length is, the smaller need be the number of ampère-turns of circulation. Therefore you should design the electro-magnet as stumpy as possble, that is to say, make it a stumpy arch, even as Joule did when he came across the same problem, and arrived, by a sort of scientific instinct, at the right solution. You should have no greater length of iron than is necessary in order to get the windings on. Then you see we cannot absolutely calculate the length of the iron until we have an idea about the winding, and we must settle, therefore, provisionally, about the windings. Take a simple ideal case. Suppose we had an indefinitely long, straight iron rod, and we wound that from end to end with a magnetising coil. How thick a coil, how many ampère-turns of circulation per inch length, will you require in order to magnetise up to any particular degree? It is a matter of very simple calculation. You can calculate exactly what the magnetic reluctance of an inch length of the core will be. For example, if you are going to magnetise up to 16,000 lines per square centimetre, the permeability will be 320. You can take the area anything you like, and consider the length of one inch; you can therefore calculate the magnetic reluctance per inch of conductor, and then you can at once say how many ampère-turns per inch would be necessary in order to give the desired indication of 16,000 magnetic lines to the square centimetre. And knowing the properties of copper wire, and how it heats up when there is a current; and knowing also how much heat you can get rid of per square inch of surface, it is a very simple matter to calculate what minimum thickness of copper the fire insurance companies would allow you to use. They would not allow you to have too thin a copper wire, because if you provide an insufficient thickness of copper, you still must drive your ampères through it to get a sufficient number of ampère-turns per inch of length; and if you drive those ampères through copper winding of an insufficient thickness the copper wire will over-heat, and your insurance policy will be revoked. You therefore are compelled, by the practical consideration of not over-heating, to provide a certain thickness of copper wire winding. I have made a rough calculation for certain cases, and I find that for such electro-magnets as one may ordinarily deal with, it is not necessary in any case of practical work to use a copper wire winding, the total thickness of which is greater than about half-an-inch; and, as a matter of fact, if you use as much thickness as half-an-inch, you need not then wind the coil all along, for if you will use copper wire winding, no matter what the size, whether thin or thick, so that the total thickness of copper outside the iron is half-an-inch, you can without over-heating, using good wrought iron, make one inch of winding do for 20 inches length of iron. That is to say, you do not really want more than $\frac{1}{20}$th of an inch of thickness of copper outside the iron to magnetise up to the prescribed degree of saturation that indefinitely long piece of which we are thinking, without over-heating the outside surface in such a way as to violate the insurance rules. Take it roughly, if you wind to a

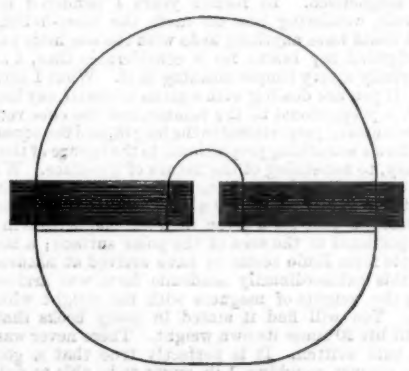


FIG. 23.—STUMPY ELECTRO-MAGNAT.

* Cantor Lecture. Delivered before the Society of Arts, January 27th, 1890.

thickness of half-an-inch, the inch length of copper will magnetise 20 inches length of iron up to the point where B equals 16,000. If then we have a bar bent into a sort of horse-shoe in order to make it stick on to a perfectly-fitting armature also of equal section and quality, we really do not want more than one inch along the inner curve for every 20 inches of iron. An extremely stumpy magnet, such as I have sketched in Fig. 23, will therefore do if one can only get the iron sufficiently homogeneous throughout. If instead of crowding the wire near the polar parts, we could wind entirely all round the curved part, though the layer of copper winding would be half-an-inch thick inside the arch, it would be much less outside. Such a magnet, provided the armature fitted with perfect accuracy to the polar surfaces, and provided a battery were arranged to send the requisite number of ampères of current through the coils, would pull with a force of one ton, the iron being but 3¼ inches in diameter. For my own part, in this case I should prefer not to use round iron, one of square or rectangular section being more convenient; but the round iron would take less copper in winding, as each turn would be of minimum length if the section were circular.

Now, this sort of calculation requires to be greatly modified directly one begins to deal with any other case. A stumpy short magnetic circuit with great cross-section is clearly the right thing for the greatest traction. You will get the given magnetisation and traction with the least amount of magnetising force when you have the area as great as possible, and the length as small as possible. You will kindly note that I have given you as yet no proofs for the practical rules that I have been using: they must come later. Also I have said nothing about the size of the wire, whether thick or thin. That does not in the least matter; for the ampère-turns of magnetising power can be made up in any desired way. Suppose we want on any magnet one hundred ampère-turns of magnetising power, and we choose to employ a thin wire that will only carry half an ampère, then we must wind 200 turns of that thin wire. Or, suppose we choose to wind it with a thick wire that will carry ten ampéres, then we shall want only ten turns of that wire. The same weight of copper, heated up by the corresponding current to an equal degree of temperature, will have equal magnetising power when wound on the same core. But the rules about winding the copper will be considered later.

Now, if you look in the text-books that have been written on magnetism for information about the so-called lifting power or portative force of magnets—in other words, the traction—you will find that from the time of Bernoulli downwards, the law of portative force has claimed the attention of experimenters, who, one after another have tried to give the law of portative force in terms of the weight of the magnets; usually dealing with permanent magnets, not electro-magnets. Bernoulli gave* a rule something of the following kind, which is commonly known as Häcker's rule—

$$P = a \sqrt[\frac{3}{2}]{W};$$

where W is the weight of the magnet, P, the greatest load it will sustain, and a a constant depending on the units of weight chosen, on the quality of the steel, and on its goodness of magnetisation. If the weights are in pounds then a is found, for the best steels, to vary from 18 to 24 in magnets of horse-shoe shape. This expression is equivalent to saying that the power which a magnet can exert—he was dealing with steel magnets; there were no electro-magnets in Bernoulli's time—is equal to some constant multiplied by the three-halfth root of the weight of the magnet itself. The rule is accurate only if you are dealing with a number of magnets all of the same geometrical form, all horse-shoes let us say, of the same general shape, made from the same sort of steel, similarly magnetised. In former years I pondered much on Häcker's rule, wondering how on earth the three-halfth root of the weight could have anything to do with the magnetic pull; and having cudgelled my brains for a considerable time, I saw that there was really a very simple meaning in it. What I arrived at† was this. If you are dealing with a given material, say hard steel, the weight is proportional to the volume, and the cube root of the volume is something proportional to the length, and the square of the cube root forms something proportional to the square of the length, that is to say, to something of the nature of a surface. What surface? Of course the polar surface. This complex rule, when thus analysed, turns out to be merely a mathematician's expression of the fact that the pull for a given material magnetised in a given way is proportional to the area of the polar surface; a law which in its simple form Joule seems to have arrived at naturally, and which in this extraordinarily academic form was arrived at by comparing the weights of magnets with the weight which they would lift. You will find it stated in many books that a good magnet will lift 20 times its own weight. There never was a more fallacious rule written. It is perfectly true that a good steel horse-shoe magnet weighing 1 lb. ought to be able to pull with a pull of 20 lbs. on a properly-shaped armature. But it does not follow that a magnet which weighs 2 lbs. will be able to pull with a force of 40 lbs. It ought not to, because a magnet that weighs 2 lbs. has not poles twice as big if it is the same shape. In order to have poles twice as big you must remember that three-halfth root coming in. If you take a magnet that weighs eight times as much, it will have twice the linear dimensions and four times the surface; and with four times the surface in a magnet of the same form, similarly magnetised, you will have four times the pull. With a magnet eight times as heavy you will have only four times the pull. The pull, when other things are equal, goes by surface, and not by weight, and therefore it is ridiculous to give a rule saying how many times its own weight a magnet will pull. It is also narrated as a very extraordinary thing that Sir Issac Newton had a magnet, a loadstone, which he wore in a signet ring, which would lift 234 times its own weight. I have had an electro-magnet which would lift 2,500 times its own weight, but then it was a very small one, and did not weigh more than a grain and a-half. When you come to small things, of course the surface is large proportionally to the weight; the smaller you go, the larger becomes that disproportion. This all shows that the old law of traction in that form was practically valueless, and did not guide you to anything at all, whereas the law of traction as stated by Maxwell, and explained further by the law of the magnetic circuit, proves a most useful rule.

From this digression let us return to the law of the magnetic circuit. I gave you in my first lecture, when speaking of permeability, the following rule for calculating the magnetic induction, B:—Take the pull in lbs., and the area of cross-section in square inches, divide one by the other, and take the square root of the quotient; then multiplying by 1,317 gives B; or multiplying by 8,494 gives $B_{,,}$. We have therefore a means of stepping from the pull per square inch to $B_{,,}$, or from $B_{,,}$ to the pull per square inch. Now the other rule of the magnetic circuit also enables us to get from the ampère-turns down to $B_{,,}$ for previously we have the following expression for the ampère-turns:—

$$s\,i = N \times \Sigma \frac{l''}{A'' \mu} \times 0{\cdot}3132,$$

and N, the whole number of magnetic lines in the magnetic circuit is equal to $B_{,,}$ multiplied by A'', or

$$N = B_{,,} A''.$$

From these we can deduce a simple direct expression, provided we assume the quality of iron as before, and also assume that there is no magnetic leakage, and that the area of cross-section is the same all round the circuit, in the armature as well as in the magnet core. So that l'' is simply the mean total path of the magnetic lines all round the closed magnetic circuit. We may then write

$$s\,i = \frac{B_{,,}\, l''}{\mu} \times 0{\cdot}3132;$$

whence

$$B_{,,} = \frac{\mu \times s\,i}{l'' \times 0{\cdot}3132}.$$

But by the law of traction, as stated above,

$$B_{,,} = 8{,}494 \sqrt{\frac{P\ (\text{lbs.})}{A\ (\text{sq. in.})}}.$$

Equating together these two values of $B_{,,}$, and solving, we get for the requisite number of ampère-turns of circulation of exciting currents:—

$$s\,i = 2{,}661 + \frac{l''}{\mu} \times \sqrt{\frac{P\ (\text{lbs.})}{A\ (\text{sq. in.})}}$$

This, put into words, amounts to the following rule for calculating the amount of exciting power that is required for an electro-magnet pulling at its armature, in the case where there is a closed magnetic circuit with no leakage of magnetic lines. Take the square root of the pounds per square inch; multiply this by the mean total length (in inches) all round the iron circuit; divide by the permeability (which must be calculated from the pounds per square inch by help of Table VI. and Table II.); and finally multiply by 2,661: the number so obtained will be the number of ampère-turns. One goes at once from the pull per square inch to the number of ampère-turns required to produce that pull in a magnet of given length, and of the prescribed quality. In the case where the pull is specified in kilogrammes, the area of section in square centimetres, and the length in centimetres, the formula becomes

$$s\,i = 3{,}951. \frac{l}{\mu} \sqrt{\frac{P}{A}}.$$

As an example, take a magnet core of round annealed wrought iron, half-an-inch in diameter, 8 inches long, bent to horse-shoe shape. As an armature, another piece, 4 inches long, bent to meet the former. Let us agree to magnetise the iron up to the pitch of pulling with 112 lbs. to the square inch. Reference to Table VI. shows that $B_{,,}$ will be about 90,000, and Table II. shows that in that case μ will be about 907. From these data calculate what load the magnet will carry, and how many ampère-turns of circulation of current will be needed.

Ans.—Load (on two poles) = 43·97 lbs.
Ampère-turns needed = 372·5

N.B.—In this calculation it is assumed that the contact surface between armature and magnet is perfect. It never is; the joint offers additional resistance to the magnetic lines, and there will be some leakage. It will be shown later how to estimate these effects, and to allow for them in the calculations.

Here let me go to a matter which has been one of the paradoxes of the past. In spite of Joule, and of the laws of traction, showing that the pull is proportional to the area, you have this anomaly—that if you take a bar-magnet having flat ended poles, and measure the pull which its pole can exert on a perfectly flat armature, and

* *Acta Helvetica* III., p. 233, 1758.
† *Philosophical Magazine*, July, 1888.

then deliberately spoil the truth of the contact surface, rounding it off, so making the surface gently convex, the convex pole, which only touches at a portion of its area instead of over the whole, will be found to exert a bigger pull than the perfectly flat one. It has been shown by various experimenters, particularly by Nicklès, that if you want to increase the pull of a magnet with armatures, you may reduce the polar surface. Old steel magnets were frequently purposely made with a rounded contact surface. There are plenty of examples. Suppose you take a straight round core, or one leg of a horse-shoe which answers equally, and take a flat-ended rod of iron of same diameter as an armature; stick it on endwise, and measure the pull when a given amount of ampère-turns of current is circulating round. Then having measured the pull, remove it and file it a little, so as to reduce it at the edges, or actually take a slightly narrower piece of iron, so that it will actually be exerting its power over a smaller area, you will get a greater pull. What is the explanation of this extraordinary fact? A fact it is, and I will show it to you. Here, Fig. 24, is a small

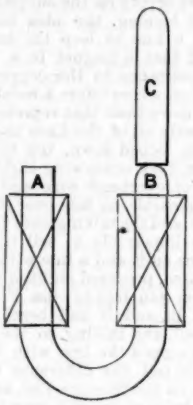


FIG. 24.—EXPERIMENT ON ROUNDING ENDS.

electro-magnet which we can place with its poles upwards. This was very carefully made, the iron poles very nicely faced, and on coming to try them it was found they were nearly equal, but one pole, A, was a little stronger than the other. We have, therefore, rounded the other pole, B, a little, and here I will take a piece of iron, C, which has itself been slightly rounded at one end, though it is flat at the other. I now turn on the current to the electro-magnet, and I take a spring-balance, so that we can measure the pull at either of the two poles. When I put the flat end of C to the flat pole A, so that there is an excellent contact, I find the pull about 2¼ lbs. Now try the round end of C on the flat pole, A; the pull is about 3 lbs. The flat end of C on the round pole B is also about 3 lbs. But if now I put together two surfaces that are both rounded, I get almost exactly the same pull as at first with the two flat surfaces. I have made many experiments on this, and so have others. Take the following case:—There is hung up a horse-shoe magnet, one pole being slightly convex and the other absolutely flattened, and there is put at the bottom, on a square bar armature, over which is slipped a hook to which weights can be hung. Which end of the armature do you think will be detached first?

If you were going simply by the square inches, you would say this square end will stick on tighter; it has more gripping surface. But, as a matter of fact, the other sticks tighter. Why? We are dealing here with a magnetic circuit. There is a certain total magnetic reluctance all round it, and the whole number of magnetic lines generated in the circuit depends on two things—on the magnetising force, and on the reluctance all round; and, saving a little leakage, it is the same number of magnetic lines which come through at B as go through at A. But here, owing to the fact that there is at B a better contact at the middle than at the edges of the pole, the lines are crowded into a smaller space, and therefore at that particular place $B_{\prime\prime}$, the number of lines per square inch runs up higher, and when you square the larger number, its square becomes still larger in proportion. In comparing the square of smaller $B_{\prime\prime}$ with the square of greater $B_{\prime\prime}$, the square of the smaller $B_{\prime\prime}$ over the larger area turns out to be less than the square of the larger $B_{\prime\prime}$ integrated over the smaller area. It is the law of the square coming in.

As an example, take the case of a magnet pole formed on the end of a piece of round iron 1·15 inch in diameter. The flat pole will have 1·05 inches area. Suppose the magnetising forces are such as to make $B_{\prime\prime} = 90{,}300$, then, by Table VI., the whole pull will be 118·75 lbs., and the actual number of lines through the contact surface will be $N = 948{,}150$. Now suppose the pole be reduced by rounding off the edge till the effective contact area is reduced to 0·9 square inches. If all these lines were crowded through that area, that would give a rate of 105,630 per square inch. Suppose, however, that the additional reluctance and the leakage reduced the number by 2 per cent., there would still be 103,500 per square inch. Reference to Table VI. shows that this gives a pull of 147·7 lbs. per square inch, which multiplied by the reduced area 0·9 gives a total pull of 132·9 lbs., which is larger than the original pull.

(To be continued.)

SOME GENERAL REMARKS ON TELEPHONE EXCHANGE CONSTRUCTION AND EQUIPMENT.*

By F. A. PICKERNELL.

THE modern telephone exchange building should be thoroughly fire-proof. False floors and concealed masses of wires should be avoided, for a fire once started in such places is extinguished with great difficulty. In its erection, everything should be sacrificed that in any way interferes with the particular object for which it is built. In the basement racks are to be provided for underground cables. Between the basement and the terminal room a cable shaft or system of ducts is to be constructed. On the top floor are to be located the operating, terminal, battery and power, cloak and lunch rooms. These rooms should be provided with chemical fire extinguishers, and the manager, fire chief, and his assistants thoroughly instructed in their use.

In case of fire every effort should be made to suppress it without calling on the fire department. If the fire should attain considerable proportions, it could at its worst only consume all the combustible matter in the room, for inasmuch as the operating room is on the top floor, the fire could not cripple any of the supporting columns or beams of the building and cause it to fall. If a small fire was started and the average fireman admitted, he would do more damage with his axe and hose than the fire would in entirely consuming the apparatus.

Before a telephone company is in a position to erect a suitable building it is necessary to make definite estimates of the probable extent of the underground work, the ultimate number of subscribers it will be desired to handle at the proposed exchange, the probable number of trunks to other exchanges, the probable number of extra territorial lines, the amount of private wire business, the probable average number of calls per subscriber per day, when the switchboard attains its ultimate capacity. A careful estimate of this kind determines the ultimate capacity of the switchboards, underground cable runs, &c., and consequently fixes the minimum size of the building.

In order that the building may fulfil the requirements of a modern telephone exchange, a technical expert should be provided with these estimates, and his opinion taken before any land is purchased or building erected. He should collaborate with the architect in making the building plans. Mistakes have already been made by telephone companies in adopting plans of good office buildings, and afterwards placing the switchboard wherever room could be found. Such buildings have been found unsuitable for modern telephone exchanges. It does not follow from this that the requirements of a good telephone building are necessarily incompatible with the demands of an office building.

One of the first matters to be considered in planning the building is the handling of the underground cables. The system for bringing in the cables should be thoroughly flexible, and permit of the drawing in and out of any particular cable when the point of ultimate equipment is reached. The cables are to be extended through the basement to vertical rows of ducts, or to a suitable cable shaft, extending to the cable terminal room. The massing of the cables in rows of ducts extending to a large number should be avoided. Wherever it is necessary to pass from one system of ducts to another system, the cable should be brought into a vertical row, thus rendering each cable accessible. Before any building plan is adopted, a complete working plan for the handling of the underground cables should be made. This working plan should show the exact location of every cable in the subway at each turn and the location of its inside terminal.

It is preferable to head up cables in a terminal containing a sneak current and lightning arrester. The sneak current arrester should operate with the current of three-tenths of an ampère in 40 seconds, and the lightning arrester should operate when the potential of the wire rises to 300 volts. By using a combined cable head and strong current arrester, economy and space as well as inexpensiveness are insured. The strong current arrester should be so designed that the lines can be tested at this point, by using suitable plugs. The terminal room should also contain a distributing board and chief inspector's desk. The most economical, compact and flexible distributing board that has yet been devised is that known as the "Hibbard iron distributing board." The cable terminals should be connected with the line side of the distributing board by flexible cable, all connections being solid. The switchboard cables terminate on its other side. For cross connecting wires, okonite wire No. 20 B. and S. gauge, insulated to $\frac{1}{32}$ of an inch, twisted in pairs, should be used, all connections being solid.

The chief inspector's desk should be located immediately in front of the distributing board and should be provided with a telephone outfit, Morse key and relay, Wheatstone bridge and galvanometer and loops extending to the tower and battery room, local switchboard and chief operator's desk. It should be provided with testing plugs for use at the strong current arrester.

Near the terminal room should be located a power and battery room, and in this room battery racks should be provided upon which operators' transmitter batteries and chief inspector's testing batteries can be located. The battery rack should be wired with waterproof wire in a permanent manner. In this room a gene-

* Read at the National Telephone Exchange Association, Detroit, September, 1890.

rator switchboard should be provided, and have terminating upon it loops to the various portions of the multiple board and also the terminals of all generators. Electric motors, water motors, or other suitable power supply, should be located here. Both the terminal room and battery and power room should be so located that it will be possible to enter them without passing through the operating room.

On the same floor and adjacent to the terminal room should be located the operating room. This room should be large and well ventilated, free from elevator shafts, columns or other obstructions. The switchboard should commence at the end of the operating room nearest the terminal room, and extend from it in a straight line. If it becomes necessary to deflect the switchboard from a straight line, it should be arranged so that the operators sit on the inside of the curve. This enables the chief operator's desk to be so located that all parts of the switchboard are visible from this point. The size of the room necessary will depend upon the ultimate capacity of the switchboard.

If the switchboard is to have an ultimate capacity of 4,000 lines or over the extra territorial trunk section should be the first in the system. It should be equipped with five-point spring jacks and three-point plugs, so that when a line is in use at the trunk section it tests busy at the other boards.

If a switchboard is to have a capacity of less than 4,000 lines, the trunk-board should be made the last section in the system, and the regular Chicago spring jack used. The reason for locating it last in the system is as follows:—Whenever a metallic circuit connection is made at any section, an open leg is attached, which extends throughout the rest of the board, to the answering jack, the open leg being shortest on connections made at the last section. In large boards, this introduces an appreciable amount of cross-talk. By making the trunk line section the last section in the board, all connections made at this board have a minimum length of open leg, and consequently the switchboard cross-talk is reduced to a minimum. The answering jack should be the last spring jack in the system, thus ensuring in every connection at least one of the parties connected having no open leg attached to his circuit. If the answering jack were the first spring jack in the section, every connection would have at least one open leg attached to it extending throughout the whole system.

Next to the trunk section comes the regular multiple board, the number of sections depending upon its present equipment. It has been found that the sections of multiple board six panels wide, of the hog-trough type, and having an ultimate capacity of 300 subscribers' drops, is the most desirable form of multiple switchboard. On the back of the hog-trough is to be located tubular clearing-out drops and tubular subscribers' drops. Immediately back of the hog-trough is to be located a cord shelf upon which both cords are to be placed. In the face of the board, immediately above the cord shelf, is to be placed the answering jacks; above the answering jacks, the subscribers' jacks.

The standard condenser listening and long-distance ringing keys with talking contacts of platinum have been found to give most excellent service. On the framework immediately under and back of the cord shelf is to be located an intermediate distributing board. It has been found that it is possible to so distribute the busy subscribers with those that are not so busy, as to make approximately equal the work for all the operators. In order to do this, without changing the number of the subscriber, the intermediate distributing board has been designed. One side of this board is connected to the answering jack and subscribers' drop, and the other side to the cables coming from the multiple board. By placing two numbers on the subscribers' drop, one on the shutter corresponding with the answering jack, and one on the face-plate corresponding with the spring jack number in the multiple board, it is possible to make cross connections at the intermediate distributing board and not change the drop number of the subscriber.

A change of this kind will be effected as follows; Suppose that the operator upon which subscriber No. 654 terminates was very busy, and that the operator upon which subscriber No. 235 terminates was not so busy; and also that the subscriber No. 654 was a very busy wire, and subscriber No. 235 was not a busy wire, it would be desirable to interchange the answering jacks of these two subscribers, for by so doing the work of the operators would be more equally divided. This would be done at the intermediate distributing board by cross-connecting the two answering jacks and by changing the face plates on these two subscribers' drops. The office record of circuits should be so constituted as to admit of this dual numbering of drops.

The double track system for intercommunication between offices is recommended. Push buttons connecting local operators with the talking circuits are to be placed within easy reach in front of each operator. All in-coming trunks should terminate on single cords, and be operated by a call wire system. For this purpose the incoming trunk line operator has his head telephone included in the talking circuit from the other exchanges. The trunk circuits should be arranged so that if the calling wire breaks down, any other trunk line may be quickly substituted, and pending the change, the trunk lines operated by drops. It is also desirable to have the circuits so constructed that when the operator at the originating office disconnects a trunk line, the operator at the receiving office is notified automatically by special signal. This reduces the number of calls on the talking circuit one-half.

In front of the switchboard, in such a position that all sections may be easily seen, a monitor desk should be placed. This desk should have, terminating on spring jacks, loops extending to each operator, to the chief inspector's desk and to circuits in the multiple board. All operating rooms should be carpeted with linoleum to prevent noise by people walking about. On the same floor as the operating room a cloak room and lunch room should be provided. The lunch room should be equipped with tea and coffee urns, lunch table, &c. By providing such conveniences for the operators a better class of women become available and exchange service correspondingly improved.

In closing these remarks I would call attention to the necessity of providing complete working plans and specifications of the proposed equipment, including the cable run, before the construction of the building is commenced. Extensive alterations in buildings and apparatus already made in several of our central offices would not have been necessary had this been done. Such plans are as necessary to the successful and economical erection of a modern telephone exchange as are the plans for the erection of a suspension bridge or other engineering work.

In the discussion which followed the reading of the paper, Mr. CARTY, gave his views briefly on the subject of "Bridging Bells" This is a system of looping, the idea being if you had more than one station on a line to loop the intermediate stations in solid. It was found that a magnet in a line had something in it besides the mere resistance to the copper. The fact that your wire is coiled around on a core offers a resistance to the telephone current a great deal more than that represented by the number of ohms of wire. In nearly all of the lines that are constructed with more than one station looped down, the talking is very poor. A line was built in New York containing eight miles of underground cable and four miles of overhead wire and 10 stations looped in solid, and it was impossible to talk over it. The bridging bells were put on that line, and the talking over it now is as near perfect as it could be. It is impossible to tell the difference between a line having 10 stations on it and a line with only two stations. Mr. Sabin, of San Francisco, procured eight of the bells and put them on a line running from San Jose to San Francisco. The line had eight stations looped in, and it had been impossible to use it for through business at all, and talking to the way stations was very poor. But having equipped the line with these bells, he reports that it is impossible to tell the difference between talking on the way line and talking on the through line, and says that the induction on the way line bridged in this way is less than it is on the through line. So that actually it has turned out that the line works better with eight stations on it than it did with only two This line is of iron, and is a grounded circuit, and these bells are simply bridged in or legged on. When lines are constructed on the bridge or multiple arc system, the construction of the wire is made much simpler. There is no bottom contact on it, and the bell rings equally well, whether the telephone is on the hook or off. In looking at some railroad troubles in Albany, I found that the drops were down and the business was paralysed. Mr. Pickernell made a suggestion that I take up some double-wound resistance coils and put them in between the drop and the ground. I did so, and that was a perfect remedy, and we ordered 50 of them and fixed it. While there it occurred to me that a bridging bell would act even better. I sent one up and it freed that line from the drop trouble. The particular bell that has been designed for this work has had introduced into it some mechanical improvements that are also applicable to the series bell. We have nut-lock binding posts, and wherever a wire was fastened by a tip these posts were put on and the wire was soldered. The lightning arrester was also taken off, because you might as well paint one on there as to to use the present one. The lightning arrester forms a point generally where a fire starts. That bell was prepared with that in view, and if lightning protection is wanted it should be provided by the most approved plan and forming a part of the general scheme of protection against any currents. I think that is briefly all there is to it. In substance, it is, that if anybody here has a line with a lot of stations on it that is not working well, if he orders some of those bells they will make it work well. The Boston people have used some of the bells, and have constructed a fifteen station line for the Armstrong Transfer Company, and they reported to me that, taking the old line at one the working of the new line might be placed at 300. The working of this system in New York has been very gratifying. We started with the New York Central Railroad and reconstructed their ticket line and equipped it with bridging bells. Then the freight people heard about it, and now the result is that we have 40 stations on three lines for that company.

A MEMBER: Are those metallic or grounded?

Mr. CARTY: Those are metallic. This practice is quite different from the ordinary looping practice. For instance, in the American Express Company—who made a big contract with us to equip them in the same way—they moved one of their stations, and we sent one of our men up and he took out the telephone, and, as had been his custom, he twisted the two ends of the wires together. That was a correct thing for him to do, as far as he knew. But it had the result, as you see here (illustrating on diagram) of just throwing the whole line out by short-circuiting it. Another man, in putting in a bridging station, drove a tack which crossed two wires together, and that prevented its bell from ringing. He started round looking for an opening, whereas he should have looked for a short circuit. So that this practice is diametrically opposed to what he had been used to. The question of an individual bell should not be confounded with this. The first thing is to get a line over which he can talk. After this is done, then that old saw of individual bells might come up again. You provide signals, and all of the stations are signalled when anybody rings. The construction of that bell is very little different from some

other bells that are made to do the work, but when you come to use 10 or 15 stations on a line you have got to have exactly that construction, and it is such an important matter to the licensees that we are making great efforts to get a patent on it. In designing that we not only have an idea of our immediate wants, but we wanted to get a bell that we could say would work on any line. Take a line with 20 stations. They are building a line now 40 miles long, of copper wire, and to be equipped with 20 stations.

Mr. GIFFORD: It would be very easy to arrange that, just as the district messenger people do with their calls coming in.

Mr. BAILEY: I want to say with reference to that system, that while the idea of telephone service is supposed to be the supplying of subscribers with an individual or single circuit, that is, a circuit on which but one telephone is placed, yet the conditions are such in a great many parts of the country, and particularly with corporations, that you cannot persuade them that it is the kind of service they want. These corporations are those that have been accustomed to telegraph systems, and they imagine that when they have a system which they can reach individually, without the intervention of a central office, that they are getting very much better service. It doesn't matter what our opinion is about that, when you try to bring those people to your way of thinking, you will find it very much of an uphill job, and the next thing to do is to accept the conditions and accommodate them. That can be done by a system of that kind. There is another advantage in that system which I think will be available in the future, and that is in the way of giving cheaper telephone service on metallic circuit lines to residences. The chief difficulty that I see about that system is on long extended lines, the liability that you have of damage to the apparatus by lightning. Our company have had for a number of years a system similar to that in operation on quite a number of lines. We have arrived at it by running a shunt wire, commencing at the first station out from the exchange. This shunt wire is passed in through the station, and the calling wire is looped through. The operation of that is, when a call has been made, the removal of the telephone opens the caller's circuit and lets the talking circuit from the earth through the shunt wire, thereby giving a free and independent wire for conversation. The talking over those lines has been magnificent. We get rid of the resistance of the coil through the circuit. I wanted to ask Mr. Carty if he found any of the effects of those coils reached the earth, as against the talking circuits. In the operation of those lines of ours we have found that in a thunderstorm the usual accidents we had were from lifting the switch and turning out the induction coils or the transmitters. That we obviated by putting a bridge there which shoves the switch to the earth, so that the current more readily passes through this direct wire than through the induction coil. I do not know whether, in this system, the ringer coils would not be subject to destruction. I think possibly there would be considerable trouble in that respect. However, it may be met by introducing some device. I should say that high resistance coils are more susceptible to damage by lightning, and when you take a line of that kind working in the country, it means stations far away and hard to reach, and therefore expensive, and a long interruption to service.

Mr. GIFFORD: That is a kind of business that it is not desirable to take.

Mr. BAILEY: But it is a kind of business you are obliged to take.

Mr. GIFFORD: I try to dodge all of that kind of business that I can.

Mr. BAILEY: But I should say, in Mr. Wilson's case in Chicago, he will find service of that kind that he cannot ignore. You must accept the situation, and devise something that will meet the demand.

Mr. GIFFORD: I do not wish to be considered as throwing any cold water on this system. I hope they will perfect their bridge bell and get a patent on it, but I do not see how it will work in all localities. Perhaps in some localities it will do. I would not know what to do with it—for instance, if I tried to use it for residence service. We make a cheap rate—all our rates are cheap (laughter); we make a cheaper rate to get some residences. You see, in Louisville, the residences are over on one side of the town, and the business portion of the city is on the other, and we debated whether we should cultivate that trade or not. At last we made a cheap residence rate, two and three subscribers on a line. Now, the Louisville woman don't want any other woman listening on her line, and they raised so much of a row that we had to do away with it.

Mr. BAILEY: Then you have had the advantage of educating those people to something better?

Mr. WILSON: Reference has been made to this question in Chicago. At one time we had quite a number of very long private lines, and the stations having been added one at a time that condition of things was permitted to go on until we found that we had a good deal of very unsatisfactory private line service. About a year ago we established a rule that we would not take any more private lines with more than five stations upon them, and we have succeeded in getting our private line business on that basis, and where a larger number of stations was required we have put in what we call our branch exchange service. For instance, the West Side Street Railroad Company have a private line of that description. They have their own exchange and their own operators. It costs them more money than it would to have a line run into our exchange at $125 a year each, although we give them a reduction in the rate. The expense of operators to them makes it a little more than they would have to pay us. In that way we have entirely eliminated the long line private wire difficulty. Now, the only objection that I see to the bridging arrangement on grounded circuits is the difficulty in locating troubles on the lines. We have been bridging our clearing-out office in Chicago for about two years, and find a great improvement. We have some very long underground lines, through cable, which were laid in the early history of the underground business, and with no margin for conversation at all. When we came to inserting the clearing-out drop in the old way it made conversation entirely impossible. After we re-wound our clearing-out branches with 300 to 500 ohms it brought the talk right up. So that I am well satisfied that the bridging scheme is the proper thing. But if you can avoid the bridging scheme and have independent lines, it is still better.

Mr. HIBBARD: This bridging-in question is a very important one. In Buffalo we have been doing a good deal of metallic circuit work for the last two years, and we had a good many combination lines, or party lines, which, after the electric lights were in operation, gave very poor service. We commenced this system of bridging-in with one or two more subscribers on a line, using first the ordinary bell, which gave us of course very poor service. Then we put in 500-ohm ringing coils. With that system and with 500 ohms in the central office, we are getting first class service with five and six on the line. We have also quite a number of private lines used by railway companies, where they have as many as eight and nine stations on the line, bridged in with 500-ohm bells, and those stations are giving splendid service.

Mr. WILSON stated that they were operating all the transmitters in the main office of the Chicago exchange with the Edison current, and are accomplishing good results. We use storage batteries. We are using at present five cells of storage batteries, which have an electromotive force of a little over two volts per cell and gives out about five ampères of current. The five cells are connected directly with the Edison current which supplies the office with light, and the storage takes place when we burn the light and we do not observe any diminution in the lighting throughout the building. There is, therefore, no expense for current. The internal resistance of each cell of the storage battery is about two-hundredths of an ohm. Consequently, as you add transmitters, it simply absorbs more current than the storage battery. The object of having five cells is that it enables us to maintain the storage battery throughout the 24 hours without its becoming exhausted. If we connected all the transmitters we would necessarily have to turn on light during the day to recharge them. Our experience has shown that with five cells it works entirely automatically. We supply between 60 and 70 transmitters.

Mr. GIFFORD: How many transmitters will one cell energise during 24 hours?

Mr. WILSON: The arrangement we have contemplates 100 transmitters. We are only operating 60.

Mr. BAILEY: How many transmitters do you couple on to one cell?

Mr. WILSON: At the present time it is about 12, and we adjust the resistance until the current in each transmitter is all that it will stand. We use the Edison current for ringing instead of the small generators.

NEW PATENTS—1890.

14927. "Improvements in telephones." G. MACAULAY-CRUIKSHANK. (Communicated by E. B. Welch, United States.) Dated September 22. (*Complete.*)

14974. "Improvements in electric meters." W. T. GOOLDEN and S. EVERSHED. Dated September 22.

15043. "Improvements in electric heating apparatus." W. R. LAKE. (Communicated by E. Abshagen, United States.) Dated September 23. (*Complete.*)

15061. "Improvements in electrical apparatus for the prevention of corrosion, and formation of scale in steam boilers." J. TELLEFSEN. Dated September 23.

15084. "Improvements in electric railway conduits with tubular conductors." C. J. VAN DEPOELE. Dated September 24. (*Complete.*) [Date applied for under Patents Act, 1883, Sec. 103, 22nd May, 1890, being date of application in United States.]

15114. "Improvements in the manufacture of plates for secondary batteries, and in the construction of such batteries." G. C. FRICKER and J. R. BAINTON. Dated September 24.

15165. "Conveying additional telegraph or telephone wires over houses and other different places after one wire or cord has already been stretched." W. J. PARKER. Dated September 25.

15191. "Improved process or method of renewing flexible carbon filaments in glow or incandescent electric lamps." C. PAUTHONIER and L'INCANDESCENCE ELECTRIQUE SOCIETE. Dated September 25.

15203. "An improved socket for incandescent electric lamps." H. H. LAKE. (Communicated by J. S. Potter, United States.) Dated September 25.

15221. "Improvements in the production of electric currents by means of air or water for lighting steamships and railway trains, and for other purposes." P. R. DE F. D'HUMY. Dated September 26.

15248. "Improvements in dynamos and electric apparatus for charging accumulator cells and running lamps at the same time."

W. B. SISLING, W. H. SCOTT, and LAURENCE, SCOTT & Co., LIMITED. Dated September 26.

15249. "Improvements in the manufacture of electrical conductors." A. MUIRHEAD. Dated September 26.

15250. "Improvements in and relating to the electric circuit connections used for lighting theatres and for analogous purposes." H. SOUTH. Dated September 26.

15251. "An improved supporting base for electric lamps and conduit for conductors therefor." H. SOUTH. Dated September 26.

15252. "An improved holder for incandescent electric lamps." H. SOUTH. Dated September 26.

15274. "A method of, and appliances for automatically utilising any excess of electricity generated for electric lighting and other purposes, and for automatically supplying any deficiency." E. B. BRIGHT and F. W. ENGELBACH. Dated September 26.

15328. "Method and devices for heating by means of electric currents." C. ZIPERNOWSKY. Dated September 27.

15337. "Improvements in or relating to electric alarm bells." J. B. M. BONNARDOT. Dated September 27.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

7165. "Apparatus for electrical distribution of energy." J. M. M. MUNRO. Dated April 30. 8d. Relates to the use of high tension continuous currents or varying strength with transformers in series or parallel. 2 claims.

8493. "Improvements in automatic cut-outs for electrical circuits." W. J. STARKEY BARBER-STARKEY. Dated May 22. 8d. The inventor includes a small dynamo or magneto-electric motor in a high resistance shunt from the dynamo or mains. By means of stops or other devices he limits the possible angular motion of the armature of this electro-motor, so that it may not rotate continuously whilst its circuit is closed. The spindle of the armature is geared or connected with a switch or device such as a mercury or brush contact, for opening and closing the main circuit. If it is required that the apparatus shall close a circuit as soon as the pressure reaches a certain amount, the force which opposes the rotation of the armature is regulated so that the armature can move only when that pressure is reached. If it is desired that the circuit should be opened as soon as the current reaches a predetermined pressure, the force opposing the rotation of the armature is regulated so that the armature will not move until that pressure is reached; in this case the main circuit is already closed, and the apparatus operates to open it; in the former case the reverse happens, that is to say, the circuit is already open, and the apparatus closes it. When the armature of the motor moves in consequence of the pressure having reached a determined amount, the motion of the armature is communicated by the connecting device to the switch or contacts, so as to open or close the circuit as hereinbefore described. When it is desired to open the circuit, if more than a determined pressure exists in the main, the motor may have one or more coils of thick wire included in the main circuit. 7 claims.

8780. "Improvements in electrical switches or cut-outs." E. E. DE FACIEU. Dated May 27. 8d. Consists essentially of a contact piece, which once set to the position of "closed circuit," is held down in that position by magnetic attraction, which magnetic attraction ceases as soon as the current conveyed by the switch increases by a definite quantity or percentage; the contact piece being then released, automatically reverts to the position of "open circuit," and stops the current. 2 claims.

8815. "Improvements and devices for automatically interrupting an electric circuit under predetermined conditions." W. P. THOMPSON. (A communication from abroad by the Westinghouse Electric Company, of America.) Dated May 28. 8d. Is designed to provide a circuit-controlling device which shall insure that the circuit leading to the filaments shall be interrupted, and the treatment thereof terminate when the resistance of the filament has decreased to a certain predetermined point. 3 claims.

12970. "Improvements in printing telegraph instruments." J. E. WRIGHT and J. MOORE. Dated August 16. 11d. According to this invention the type wheel is turned in both directions, so that it never has to perform more than a half revolution, and it is brought back to zero after every printing operation. 6 claims.

13675. "Improvements in the arrangements and apparatus for electrically lighting railway trains." W. E. LANGDON. Dated August 30. 8d. Relates to the employment of an improved electrical coupling for connecting the several cables or wires through from vehicle to vehicle, and for automatically, under certain conditions, connecting together and disconnecting certain of the said cables or wires. And in the employment in connection with certain of the said cables in each vehicle electrically lighted, where the system of electric lighting is that known as the "parallel" system, of an electrical resistance automatically operated so that when the current from the dynamo is in operation, the said resistance shall be thrown into the lighting circuit of the said vehicle, and when the current from the dynamo is not in operation, the said resistance shall be cut out of the lighting circuit. Also in the employment upon any electrically lighted vehicle, of a special device for the purpose of enabling the electrical condition of the batteries or accumulators of the said vehicle to be readily ascertained, and for providing against injury to the batteries by "short circuiting" at such points. Also in making suitable provision for obtaining ready access to the electric lamps for cleaning and for other purposes. 8 claims.

IDENTITY OF STRUCTURE BETWEEN LIGHTNING AND THE DISCHARGES OF INDUCTION MACHINES.

DURING the storm which burst over Meudon on May 8th, 1890, at about half-past six in the evening, the flashes of lightning, which were frequent and very high, took in nearly every case a horizontal direction; later on, when the rain had commenced, they were vertical, darting from the cloud to the horizon. The horizontal flashes were distinguished by a well-defined arborescent form, the numerous ramifications of which were lost in the cloud. For the most part they appeared singly, but between 6.50 and 7.10 in several instances two were seen at once, coming to meet one another from opposite directions.

One of these pairs of flashes, which subtended an angle of more than 90°, appeared in front of me, under conditions peculiarly favourable for observation. They appeared simultaneously; two separate points of the cloud were lighted up at the same instant, and two dazzling masses of light darted towards each other dividing into several branches, which in their turn were subdivided into smaller ones. The meeting, which seemed inevitable, did not, however, take place; although the extremities of the opposite branches were only separated by a space of less than 10°.

These flashes, writes M. E. Trouvelot to the *Academie des Sciences*, which lasted long enough to enable one to see clearly the form they took, were a revelation to me. It was no longer two flashes of lightning that I saw, but two electric sparks, absolutely similar, except as regards their magnitude, to the sparks of induction machines, which have become so familiar to me by long study, that I can recognise their characteristics at a glance.

In these arborescent forms, I noted that the one which came from the north, against the wind, and the branches of which were sinuous and undulating, had the appearance that is characteristic of the discharges of the positive pole of induction machines, whereas the one that came from the south, in the direction of the wind, and the zigzag branches of which deviated abruptly at right angles, had the appearance that characterises the discharges of the negative pole.

My observations seem to me conclusive; they show that in certain storms, which I will term *dry storms*, the electric discharges termed *lightning* act almost like those of our machines on bodies that are only slightly conductive, and have almost the same structure. If even there were any doubt about the characteristic forms which I observed, the very fact that two branched flashes advance towards one another and almost meet, is sufficient to prove that the sources of electricity which provoked them must be of contrary natures.

On the occasion in question, I could only observe very imperfectly, on account of its great distance, the flash uniting one cloud to another, or to the earth, by a line of fire. However, judging by analogy, and what I have observed since, and also by the examination of several photographs of flashes of lightning, there seems to be no doubt that this kind of lightning corresponds to the discharges of the opposite poles of machines, when they are united by a powerful spark.

From these observations it follows: 1st, that the arborescent flash electrifies the cloud by discharging itself upon it, as the discharges of machines electrify the sensitive plate; 2nd, that it can go down or up, horizontally or obliquely, in short, that it may take any direction; 3rd, that it varies in form according as the

storm is dry or accompanied by rain, and is more complicated in the first case. Lastly, the arborescent and complicated form of the flash not appearing on one plane, but at variable distances, explains the characteristic noise of thunder.*

A NEW SAFETY LAMP FOR MINES.

Note by M. CHARLES POLLAK.
(SUBMITTED TO THE FIRE DAMP COMMITTEE.)

THE following is a brief description of this lamp :—

A rectangular box of ebonite contains some accumulators of the Pollak type ; † this box rests on a metal tray. An ebonite lid serves as a support for an incandescence lamp, which is enclosed in a cylinder of thick glass. The whole is covered with a metal cap, fastened by means of bolts. A sheet of soft gutta-percha, interposed between the lid and the box, closes it hermetically. Rods of inoxidisable metal are inserted in the lid, passing right through it ; at their bases are platinum contacts which rest upon platinum contacts in the accumulators, and at their other extremities are springs, one of which is connected metallically with one foot of the lamp. The other foot is insulated, and can be brought into contact with one pole of the accumulator by means of a needle which is introduced into a horizontal groove in the lid.

The contacts being on the inside of the box and the lid, neither the opening nor the closing of the circuit can cause any explosion. Thus the lamp may be lighted or extinguished in an inflammable atmosphere. If the system is thrown out of working order, or if the protecting glass cylinder is broken, the lamp is extinguished.

The lamp is charged, without being taken to pieces, by means of a fork, which is introduced into two grooves hollowed out in the lid.

The model in existence weighs about 1,800 gr., and gives, on an average, 12 hours of perfectly constant light, the power of which = ·7 to ·8 of a candle-power. —*Comptes Rendus.*

CORRESPONDENCE.

Electrical Heterodoxy.

I am glad Mr. Sutton has come to the conclusion that a continuance of this correspondence would be a waste of your valuable space. Other duties occupy all my present time, but if spared I intend writing an article which shall be headed *What is Induction?* And in it this whole subject shall be embraced. In the mean time, I ask Mr. Sutton to bear in mind that when Faraday abandoned the theory of action at a distance he saw the necessity of devising something as being the cause of the various phenomena to which he gave the name of *induction*. For this purpose he invented the idea of two electric forces. To the action of these two forces he attributed all the effects which he called *induction*. Whereas in Mr. Sutton's first letter he gave a diagram and explanation of it, which showed that he believed in that which Faraday called induction, and yet Mr. Sutton maintained that there was no need to believe in Faraday's two forces. If Mr. Sutton had proceeded to state something as a substitute for Faraday's two forces all might have been well, but he did not do so, and therefore left others to conclude that he believed that an effect might be produced without a cause.

This is only one of the fundamental errors about electricity contained in Mr. Sutton's first letter which, if I had answered fully, would have led to a lengthened correspondence, which would have occupied uselessly much of your valuable space. If Mr. Sutton will not read in private a book that will give him much-needed information about electricity, he cannot expect that his lucubrations about electricity will be answered in the public prints.

Mr. Sutton is wrong in his surmise about the insulated gas-flame test. In your leading article you expressed no doubt of the accuracy of this test, and all the various parties who have seen my experiments with it from the year 1839 till now have been convinced that I am right.

Pith balls and similar substances, when placed between two bodies between which a current of electricity is passing, always oscillate between the two bodies, and therefore pith balls give no indication of the direction in which the current of electricity is moving; but an insulated gas flame never oscillates—it always bends steadily in the direction in which a current of electricity is moving, and hence its value as a test.

James Johnstone.

13*th October*, 1890.

Mutual Telephone Company and Yorkshire Telephone Company.

Can you kindly inform me through your next issue how far the above companies are developed, and whether they have commenced actual work yet? Also, whether any other companies are applying for licenses?

Telephone.

October 13*th*, 1890.

The National Telephone Company and Muirhead, Glasgow.

In your last week's issue you refer at length to a letter of mine that appeared in the *North British Daily Mail*, Glasgow. My letter referred to several points, but I shall first refer to the one which you are sceptical of, as you do not think that the National Telephone Company could be guilty of such an act of tyranny as I impeach them with. I enclose herewith six original letters from the National Telephone Company, addressed to myself. In justice to me you will, I am sure, publish them, as they bear out my statement that the National Telephone Company's vice-chairman, Col. Jackson, and the chairman of the Glasgow Board, invited me to bring from France a number of Ader and Berthon Telephones, which they kept in their possession for about two months, then ordered me, on pain of an action at law, to return them. This I declined to do, but offered to send them to the Glasgow office ; but as they did not at first accept this offer, I withdrew that also.

They then, in defiance of the clearest evidence, denied I had ever signed a contract for the use of their exchange telephone, which they removed without the usual six months' notice, though their own directory and other printed rules says, "every subscriber must sign a contract," &c.

They get their subscribers to sign contracts which they themselves keep, so that they can blow hot and cold with the same breath.

They have neither the courage to deny those statements I have publicly made nor the manliness to own themselves wrong.

The proposed demonstration will be with an *Ader receiver* and a *Gower receiver*, used as a transmitter, both of which I believe are free on 9th December. With this Ader receiver you can hear though some

* Photographs of direct discharges of electricity from the cloud to the sensitive plate might prove of great service in the study of lightning. We have already made some attempts in this direction, but unsuccessfully, with a captive balloon which had been kindly placed at our disposal by Commandant Renard, whom we take this opportunity of thanking. Experiments of this nature would no doubt have greater chances of success, if they were made at elevated parts of the globe.

† Presented to the Academy, March 17th, 1890.

yards from it, when speech is transmitted by a Berthon transmitter.

A. Erskine Muirhead.

14*th October*, 1890.

The National Telephone Company, Limited.
Glasgow Offices, Royal Exchange Buildings,
13*th March*, 1890.

A. E. Muirhead, Esq.

Dear Sir,—Referring to your interview with Col. Jackson and myself this morning, I shall be pleased if you will send on to London two Ader receivers, No. 3 in your catalogue, and four of the same, here, and two of the Poste Berthon transmitters, No. 117 in your catalogue, to London, and four of the same here.

The above to be sent on loan for trial here and in London.—Yours truly, WM. ALEX. SMITH, *Chairman of Glasgow Board.*

The National Telephone Company, Limited,
Glasgow Offices, Royal Exchange Buildings,
9*th June*, 1890.

A. E. Muirhead, Esq., Cart Forge, Crossmyloof.

Dear Sir,—I am much obliged to you for the loan of the French instruments, which I now return. Please receive herewith three Ader receivers, two Ader transmitters, two Berthon transmitters and one Berthon-Ader combined with magneto.—Yours truly,

W. AITKEN, *Engineer.*

The National Telephone Company, Limited,
Oxford Court, Cannon Street, London, E.C.,
25*th June*, 1890.

A. E. Muirhead, Esq., Glasgow.

Dear Sir,—We are in receipt of your letter of 24th and also of "Gower" instrument. This instrument is a distinct infringement of our patent rights, and by importing it you have rendered yourself liable to proceedings for an injunction and for damages. As you have sent the instrument evidently in good faith we return it to you, but at the same time we must insist on your returning it and any other similar instruments to France forthwith, or we shall have to institute proceedings against you, and we shall require a declaration from you that this has been done.

As I mentioned to you in mine of 11th inst., we cannot see our way to accepting your proposal as to royalties. I must also inform you that we do not sell any instruments.—Yours faithfully,

T. BLAIKIE, *Secretary.*

The National Telephone Company, Limited,
Oxford Court, Cannon Street, London, E.C.,
5*th July*, 1890.

A. Erskine Muirhead, Esq., Glasgow.

Dear Sir,—We are in receipt of your letters of 26th and 28th ult., and in reply have to state that we cannot have the telephones left in Glasgow, but must now ask you to send them up to us here within a week.

You are quite in error as to your being able to do as you choose in December next, as stated in your letter of 26th ult., so far as our patents are concerned.—Yours faithfully,

T. BLAIKIE, *Secretary.*

The National Telephone Company, Limited,
Oxford Court, Cannon Street, London, E.C.,
19*th August*, 1890.

Mr. A. E. Muirhead, Glasgow.

French Telephone Instruments.

Dear Sir,—With reference to previous correspondence in this matter, we must ask you to be good enough to send these instruments in to our Glasgow office, in compliance with your offer to do so contained in your letter of 28th June, 1890.—Yours faithfully,

A. ANNS, *for Secretary.*

The National Telephone Company, Limited,
Oxford Court, Cannon Street, London, E.C.,
29*th August*, 1890.

A. E. Muirhead, Esq., Glasgow.

Sir,—As we have no reply to our letter of 19th inst., I have now to inform you that unless we hear from you on or before Wednesday next, 3rd September, we shall instruct our solicitors to proceed in the matter without further notice.—Yours faithfully, ALBERT ANNS, *for Secretary.*

A Phenomenon, indeed!

Will you please explain the cause of a phenomenon which occurred the other day? I was filling up some 23 L. accumulators (new positive plates) with the usual solution of dilute acid, and the liquid was not particularly clean, so I put an iron gauze strainer across top of plates

This gauze was touching both poles of the cells, and when the acid reached it—the glass being then nearly full—a perceptible fusing was noticed between edges of gauze and poles of accumulator. Is this due to an electrical or a chemical action?

An answer will greatly oblige, and receive the thanks of

Hypothesis.

October 13*th*, 1890.

[If the gauze made a short circuit between the poles of the cell, we do not know what other result could be expected than the fusing of the metal. The fact that the occurrence did not take place until the acid reached it appears accidental only.—EDS. ELEC. REV.]

Candle-Power of Electric Lamps.

In your issue of the 3rd inst., you drew attention to the exaggeration of candle-powers in arc and incandescent lighting.

With arc lighting, I think most engineers take account of this and allow somewhere about 600 effective candle-power for an arc of 2,000 nominal C.P., as in the tests carried out at Berlin, but with incandescent lighting little or no reduction is needed.

As a matter of general interest I send you the results of some tests carried out at the Vienna Central Station in 1888. The lamps burnt out at the two Court theatres were replaced by the company, and as these amounted to somewhere about 25,000 per year, it was of the greatest importance to choose between the different makers. Five of each make were taken, and lighted from a constant pressure of 100 volts, the pressure of the lamps, the current being taken from a reserve battery and the pressure exactly adjusted. Each day the lamps were taken out singly and measured on the photometer, filament broadside on, and the sum of the candle-powers of each make plotted out.

Lamp Curves.—Watts per Candle.

Hours burning.	Swan.		Allgemeine Electric Ges.		Siemens and Halske.		Edison-Paris.		Khotinsky.	
	C.P.	Watts.	C.P.	Watts.	C.P.	Watts.	C.P.	Watts.	C.P.	Watts.
100	18·8	3·45	16·3	3·31	14·3	3·41	32·8	4·15	13·8	3 6
200	17·2	3·79	14·3	3·66	12·3	3·84	28·1	4·85	12·5	3·79
300	15·6	4·1	13·4	3·87	11·1	4·2	26 3	5·25	11·2	4 22
400	15·2	4·17	11·8	4·33	10·5	4·33	23·2	5 9	9 6	4·75
500	14·8	4·29	11·1	4·59	9·7	4·74	21 0	6·5	9·4	4·8
600	14·4	4·38	10·1	5·01	9·3	5·01	16·5	8·3	8·9	4·98
700	14·1	4·5	8·9	5·51	8·3	5 36	—	—	7·8	5·49
800	13·3	4·68	7·8	5·79	7·8	5·67	—	—	6·9	5 96
900	12·4	4·9	8·0	5·9	7·1	5·95	—	—	6·6	6·1
Avrge.	15·1	4·25	11·3	4·66	10·05	4·72	24·7	5 83	9·6	4·85

If a lamp broke it reduced the total height of the curve. The splendid instruments in the possession of this station ensure the reliability of these figures. Allowing for improvements in the Edison-Swan Company's manufacture during the last two years, and taking the mean candle-power as representing the mean effective illumination of a building, I think one can fairly speak of a 16 C.P. lamp at 4¼ watts per candle with a life of 1,000 hours.

The fact of the matter is, that the present 16 C.P. lamp is the old 20 C.P. nominal. Mr. Preece, I believe, has made some valuable experiments in gas lighting at the General Post Office, which would bear on the case as regards the behaviour of gas burners under similar conditions.

S. T. Dobson.

October 14*th*, 1890.

WE have received a letter on "The Labour Question," but as the writer does not favour us with his name and address we hold it over. Perchance our correspondent may think fit to conform to our custom, and his communication will then appear in due course.